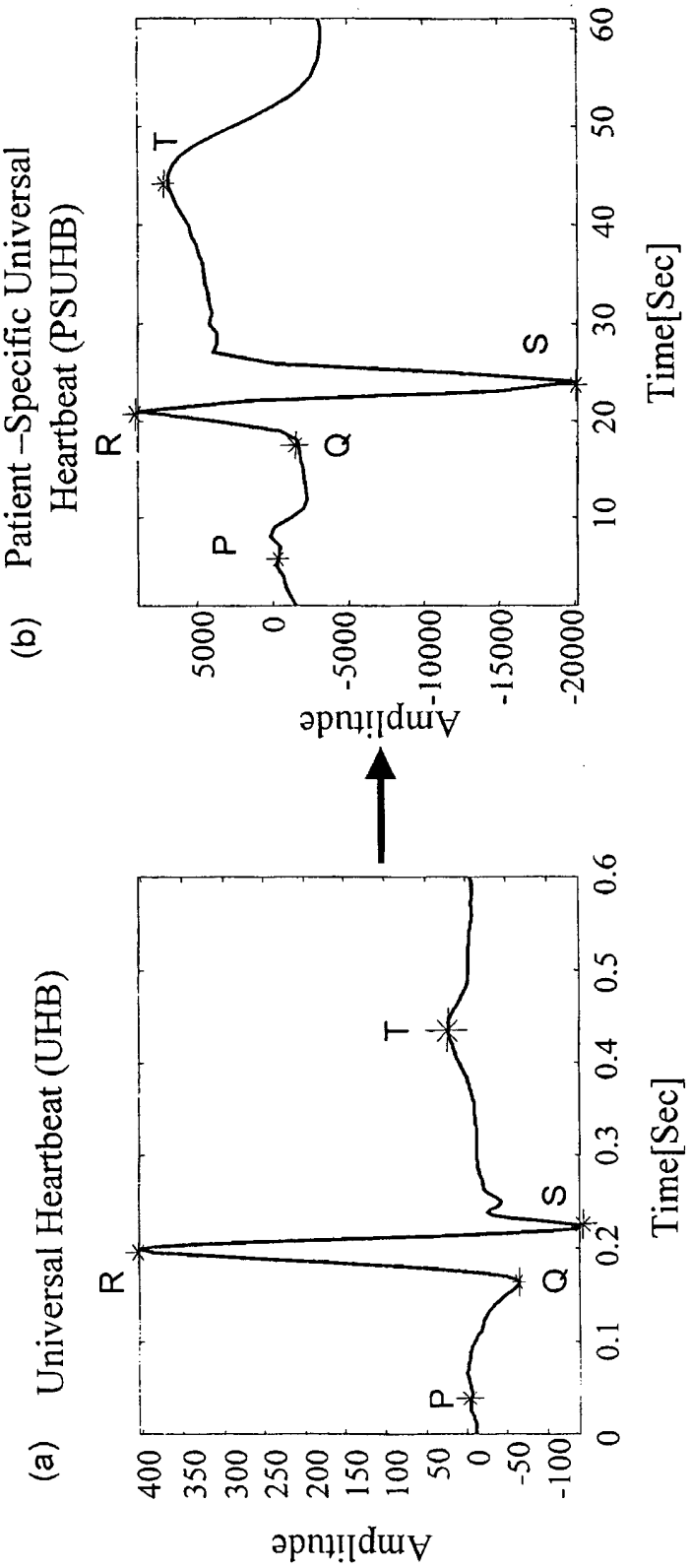

(a) Universal Heartbeat (UHB)
Amplitude
Time[Sec]
R
P
Q
S
T
(b) Patient –Specific Universal Heartbeat (PSUHB)
Amplitude
Time[Sec]
R
P
Q
S
T

Fig. 1

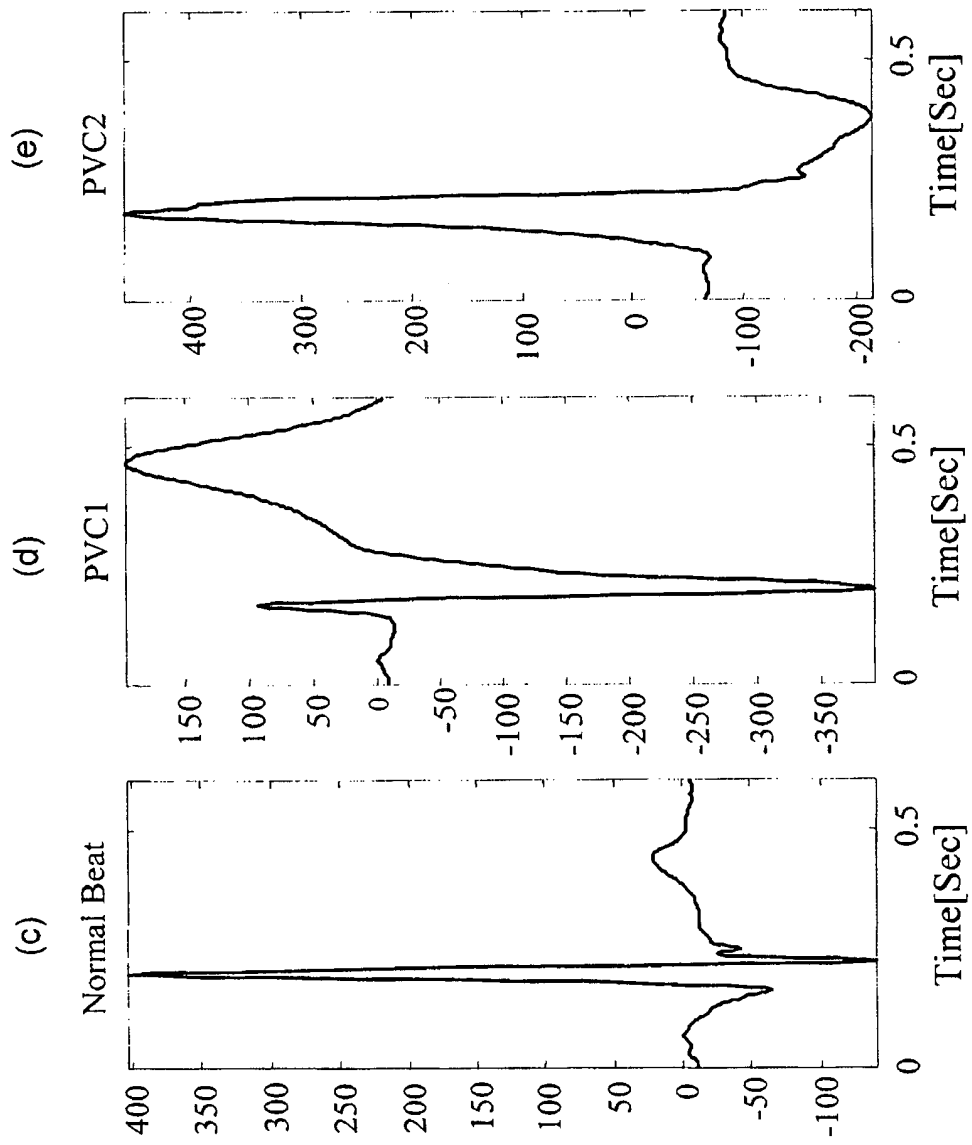


Fig. 1(cont.)

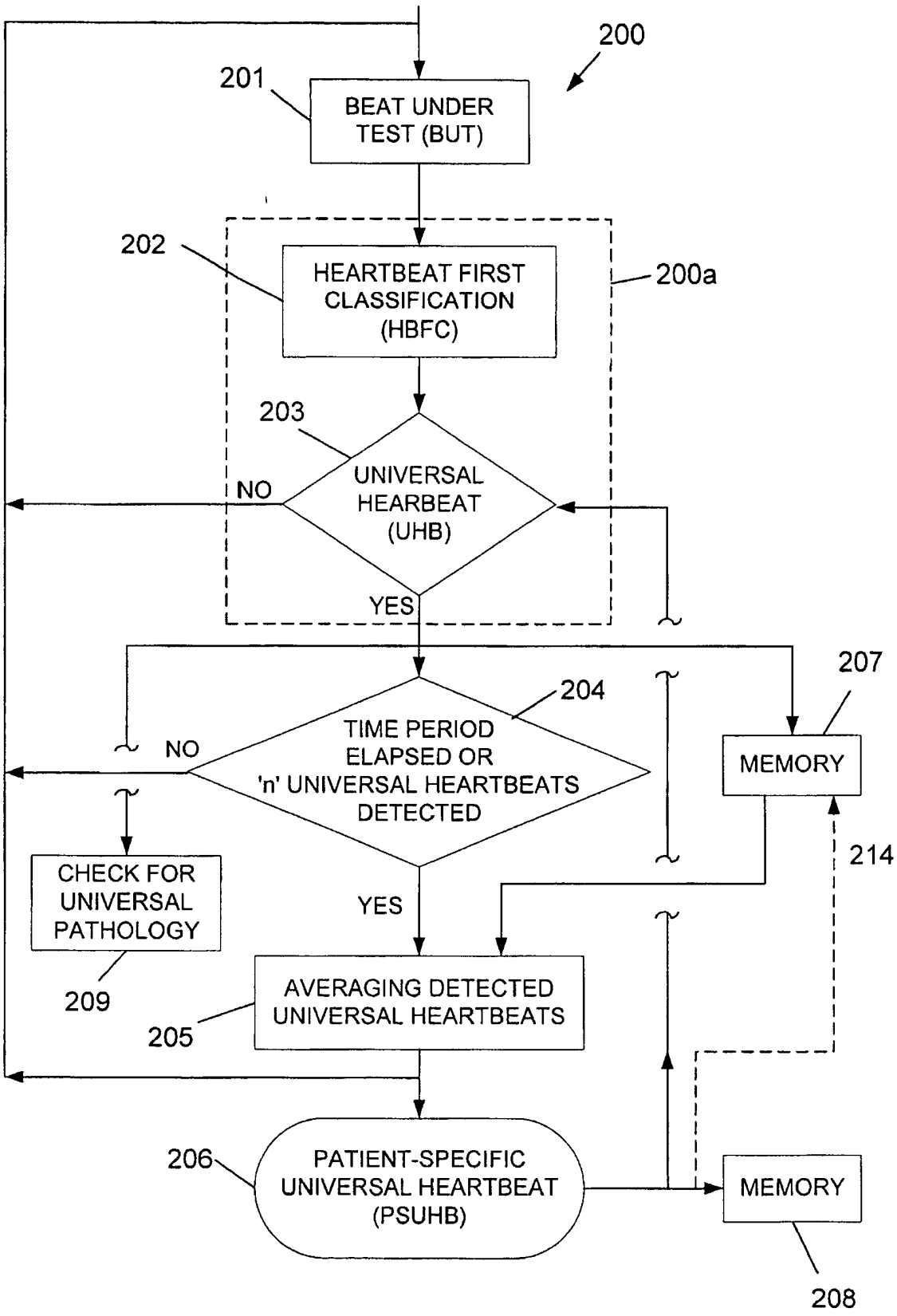

200
201
BEAT UNDER TEST (BUT)
202
HEARTBEAT FIRST CLASSIFICATION (HBFC)
200a
203
UNIVERSAL HEARBEAT (UHB)
NO
YES
207
204
TIME PERIOD ELAPSED OR 'n' UNIVERSAL HEARTBEATS DETECTED
NO
MEMORY
214
CHECK FOR UNIVERSAL PATHOLOGY
209
YES
AVERAGING DETECTED UNIVERSAL HEARTBEATS
205
206
PATIENT-SPECIFIC UNIVERSAL HEARTBEAT (PSUHB)
MEMORY
208

Fig. 2

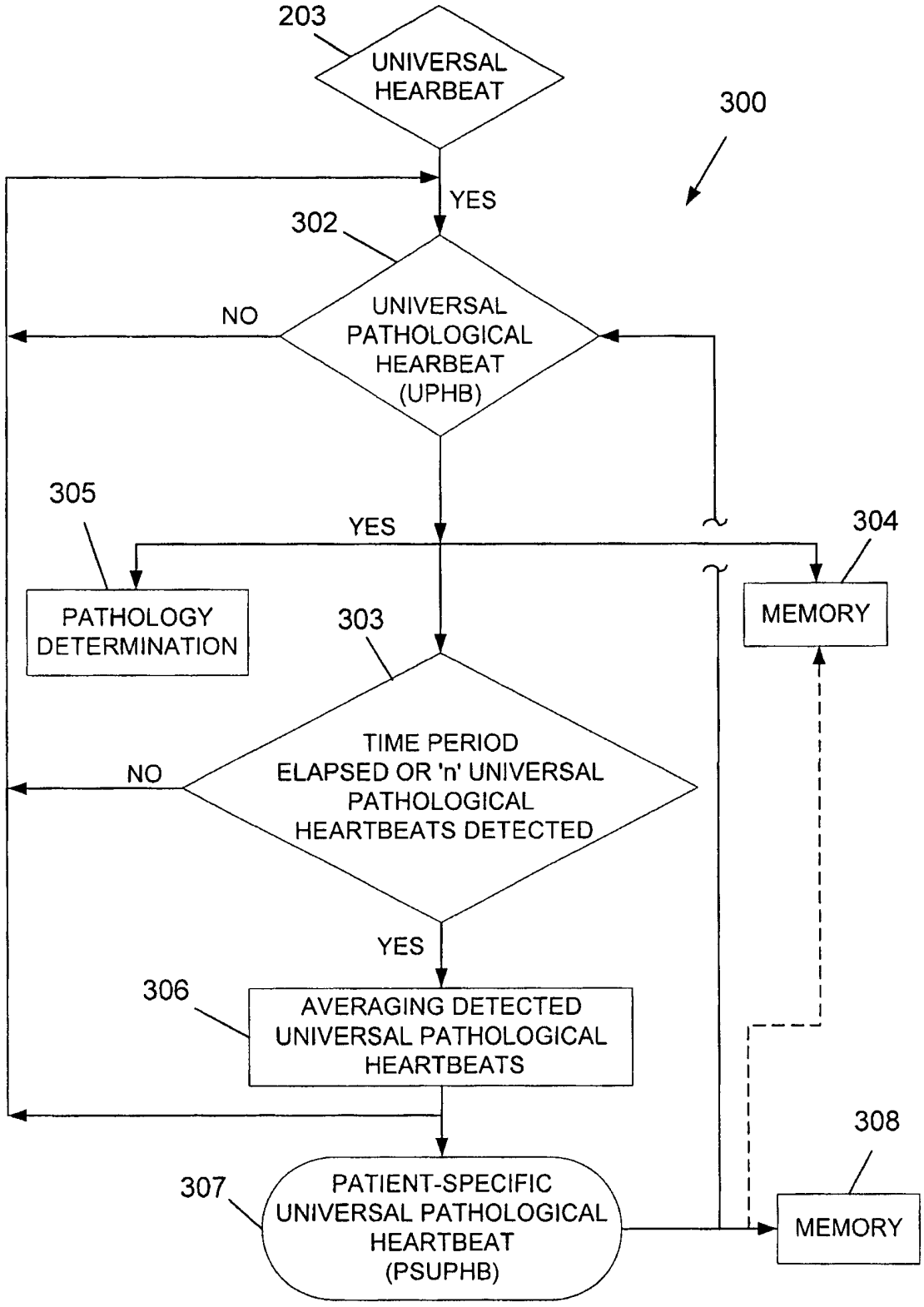

203
UNIVERSAL HEARBEAT
300
YES
302
NO
UNIVERSAL PATHOLOGICAL HEARBEAT (UPHB)
305
YES
304
PATHOLOGY DETERMINATION
303
MEMORY
NO
TIME PERIOD ELAPSED OR 'n' UNIVERSAL PATHOLOGICAL HEARTBEATS DETECTED
YES
306
AVERAGING DETECTED UNIVERSAL PATHOLOGICAL HEARTBEATS
308
307
PATIENT-SPECIFIC UNIVERSAL PATHOLOGICAL HEARTBEAT (PSUPHB)
MEMORY

Fig. 3

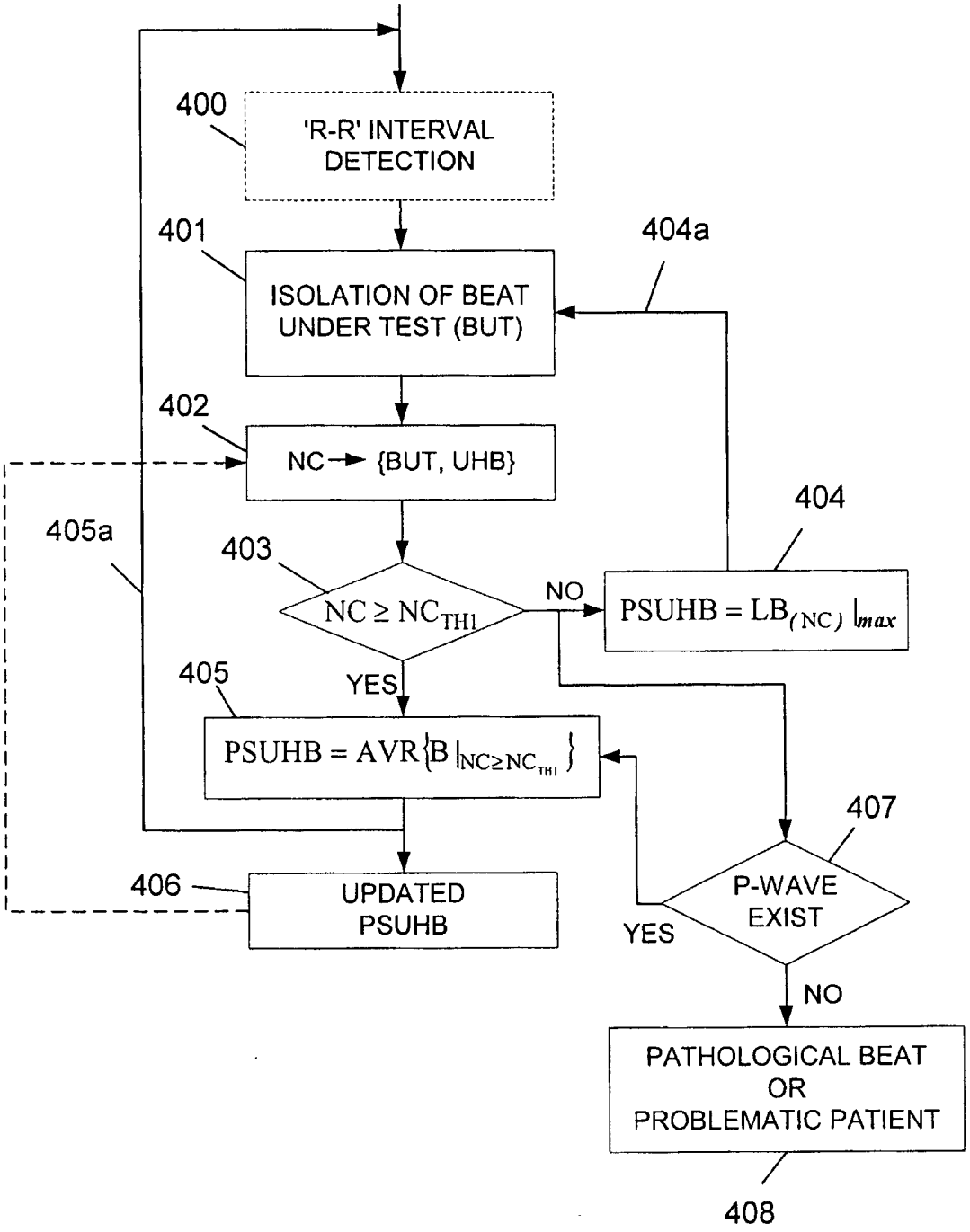

400
'R-R' INTERVAL DETECTION
401
ISOLATION OF BEAT UNDER TEST (BUT)
404a
402
NC → {BUT, UHB}
404
405a
403
NC ≥ NC_TH1
NO
PSUHB = LB_(NC) |max
405
YES
PSUHB = AVR{B |NC≥NC_TH1}
407
406
UPDATED PSUHB
P-WAVE EXIST
YES
NO
PATHOLOGICAL BEAT OR PROBLEMATIC PATIENT
408

Fig. 4

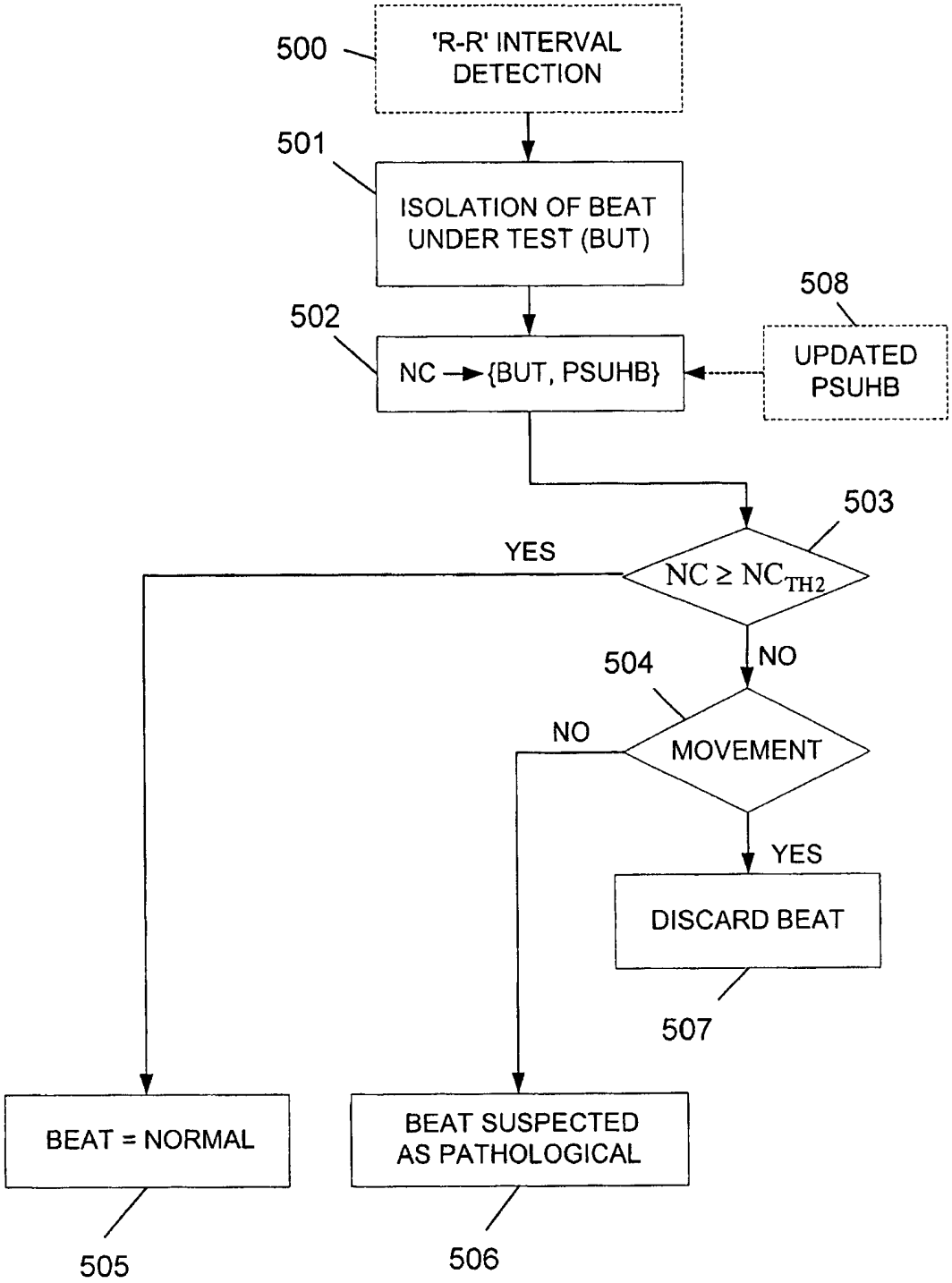

500
'R-R' INTERVAL DETECTION
501
ISOLATION OF BEAT UNDER TEST (BUT)
502
NC → {BUT, PSUHB}
508
UPDATED PSUHB
503
NC ≥ NC_TH2
YES
NO
504
MOVEMENT
NO
YES
DISCARD BEAT
507
BEAT = NORMAL
BEAT SUSPECTED AS PATHOLOGICAL
505
506

Fig. 5

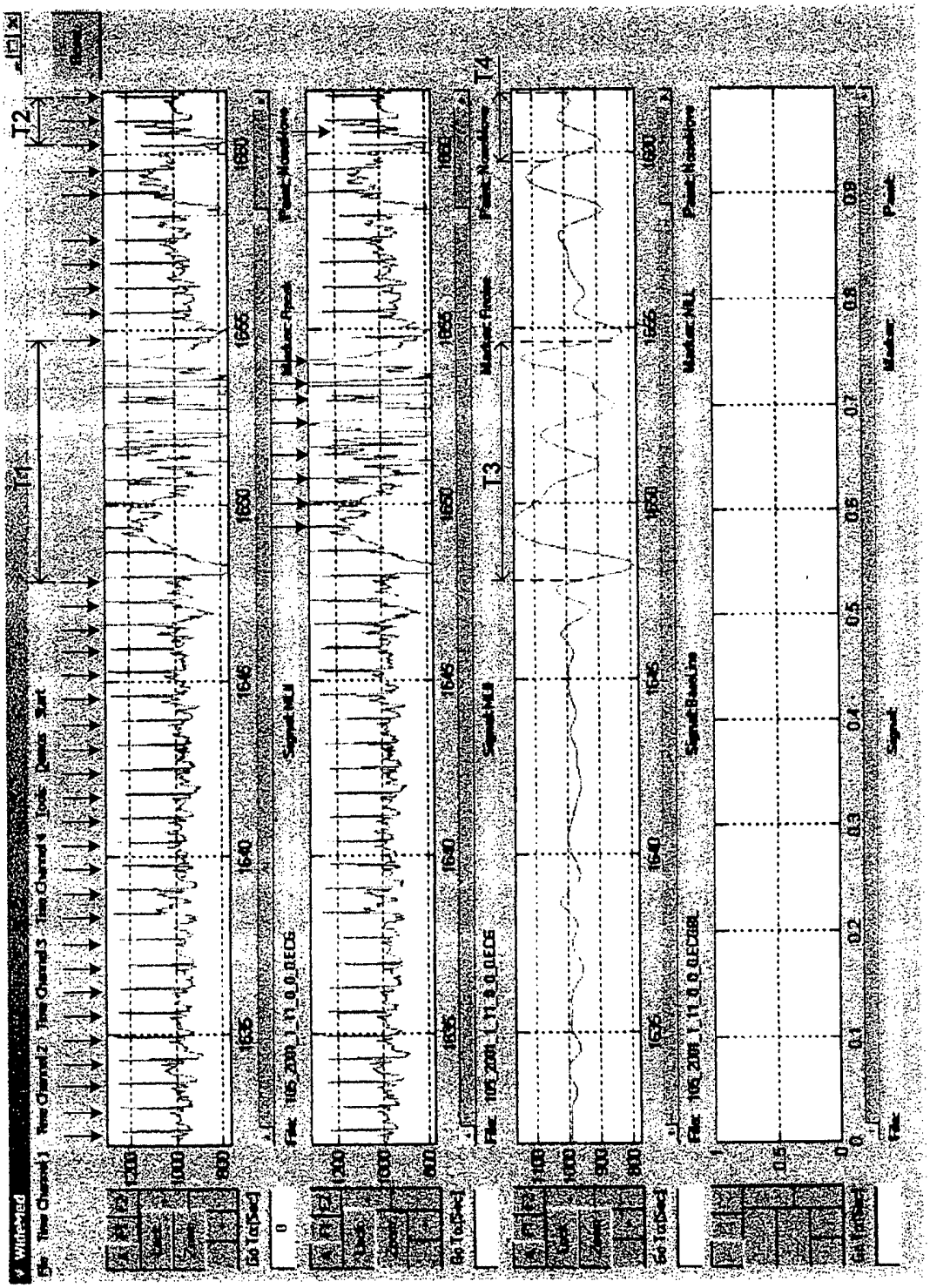


Fig. 6

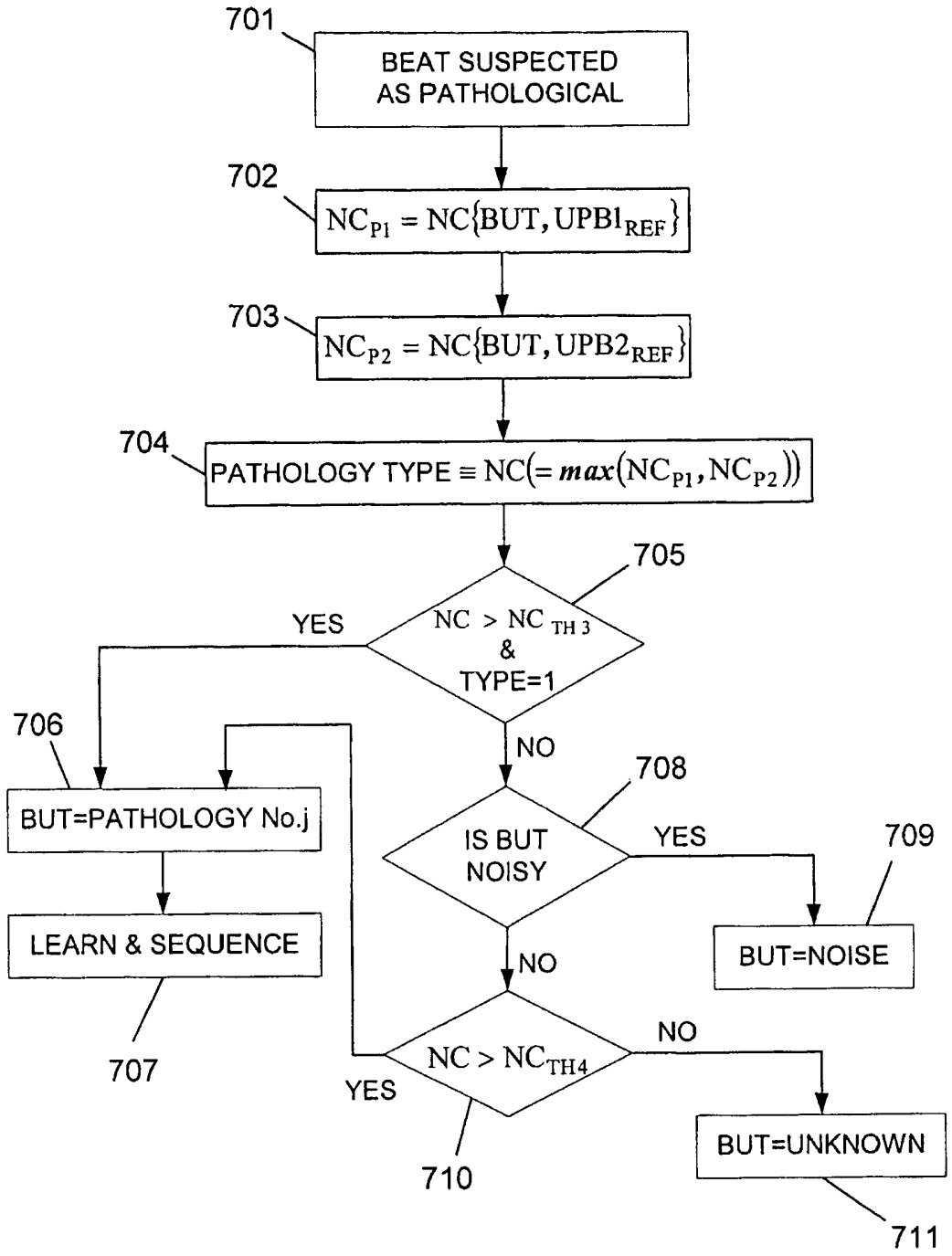

701
BEAT SUSPECTED AS PATHOLOGICAL
702
$NC_{P1} = NC\{BUT, UPB1_{REF}\}$
703
$NC_{P2} = NC\{BUT, UPB2_{REF}\}$
704
PATHOLOGY TYPE ≡ $NC(= max(NC_{P1}, NC_{P2}))$
705
NC > NC TH 3 & TYPE=1
YES
NO
706
BUT=PATHOLOGY No.j
LEARN & SEQUENCE
707
708
IS BUT NOISY
YES
709
BUT=NOISE
NO
NC > NC_{TH4}
NO
YES
710
BUT=UNKNOWN
711

Fig. 7

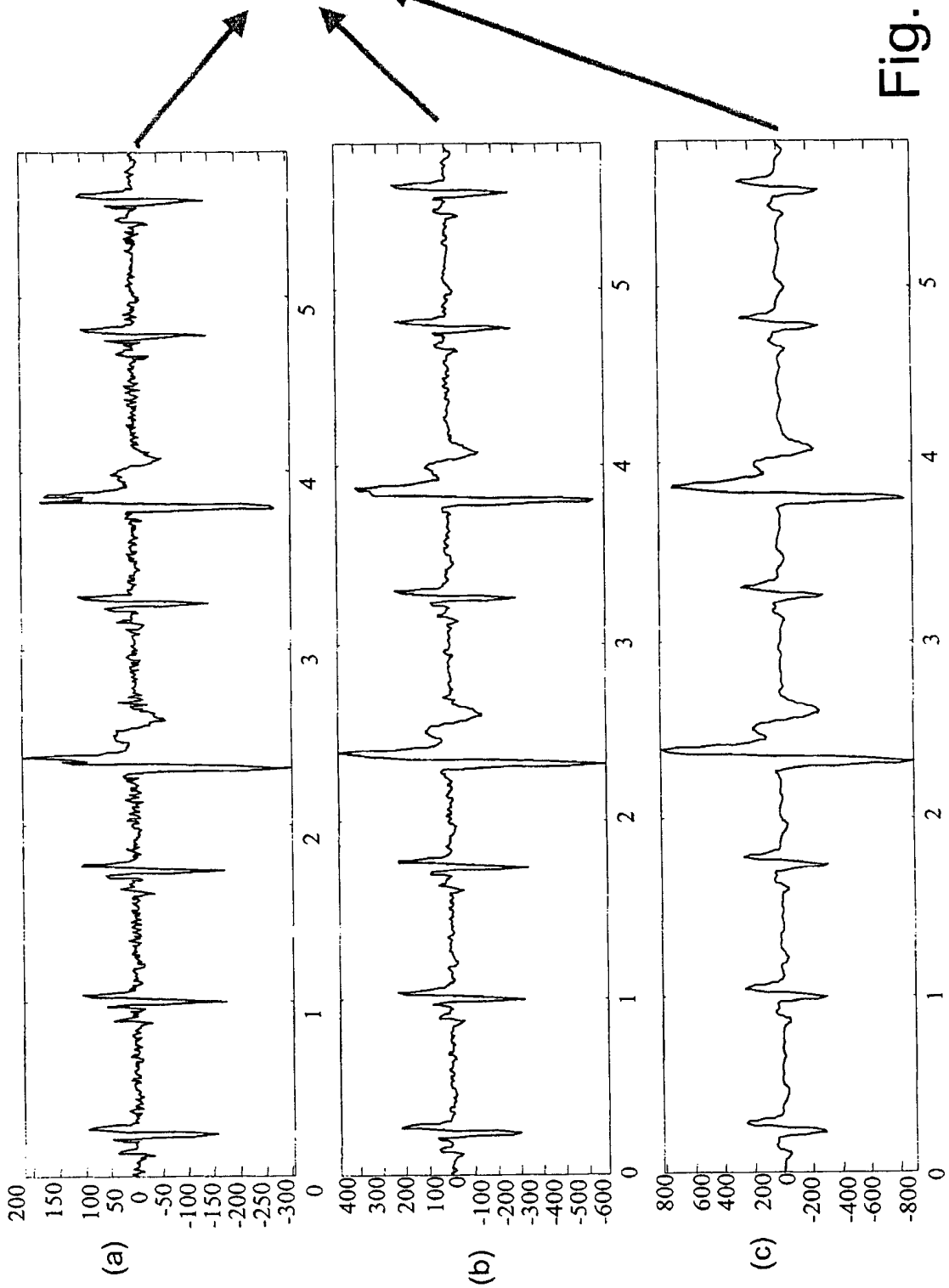


Fig. 8

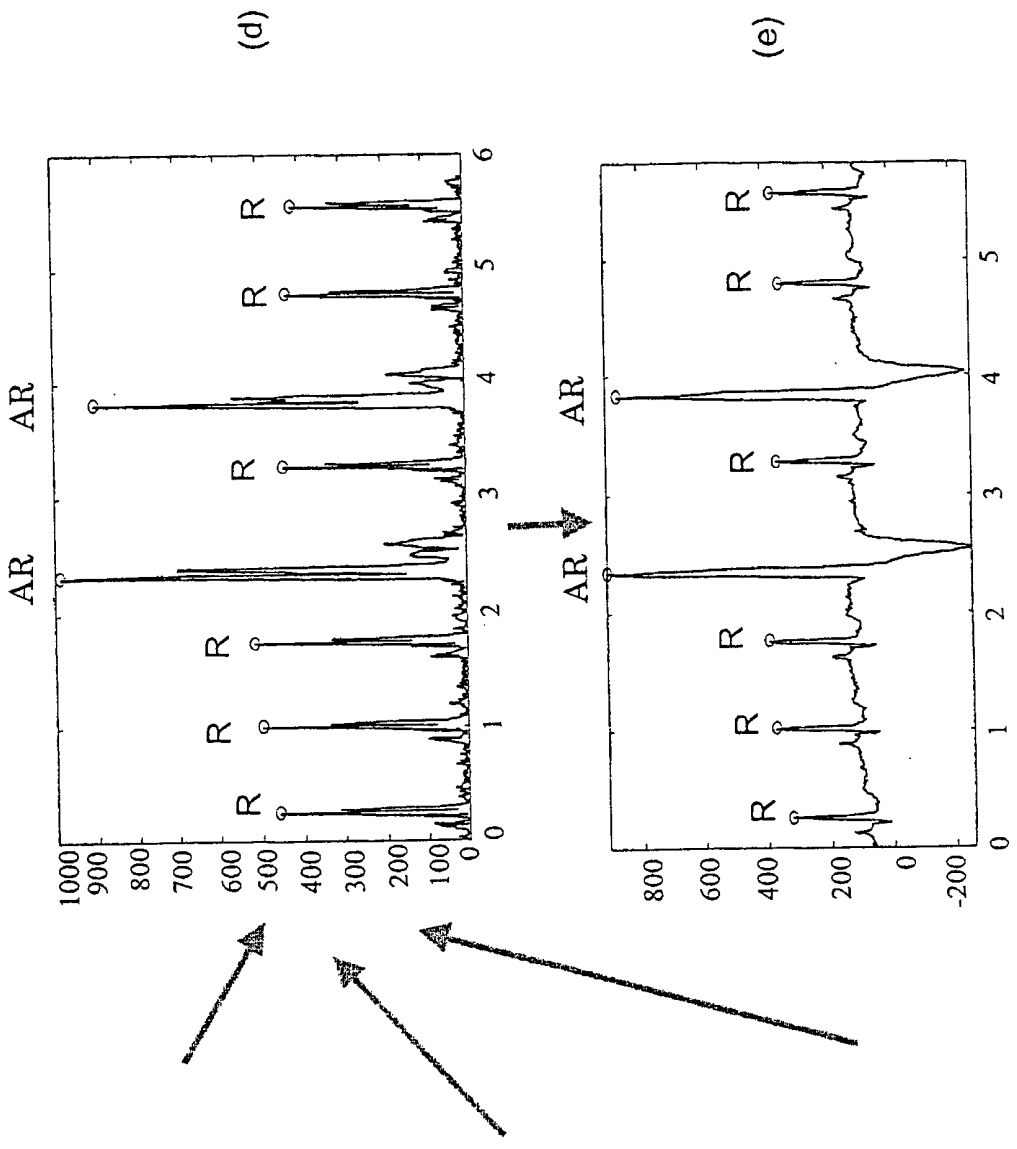
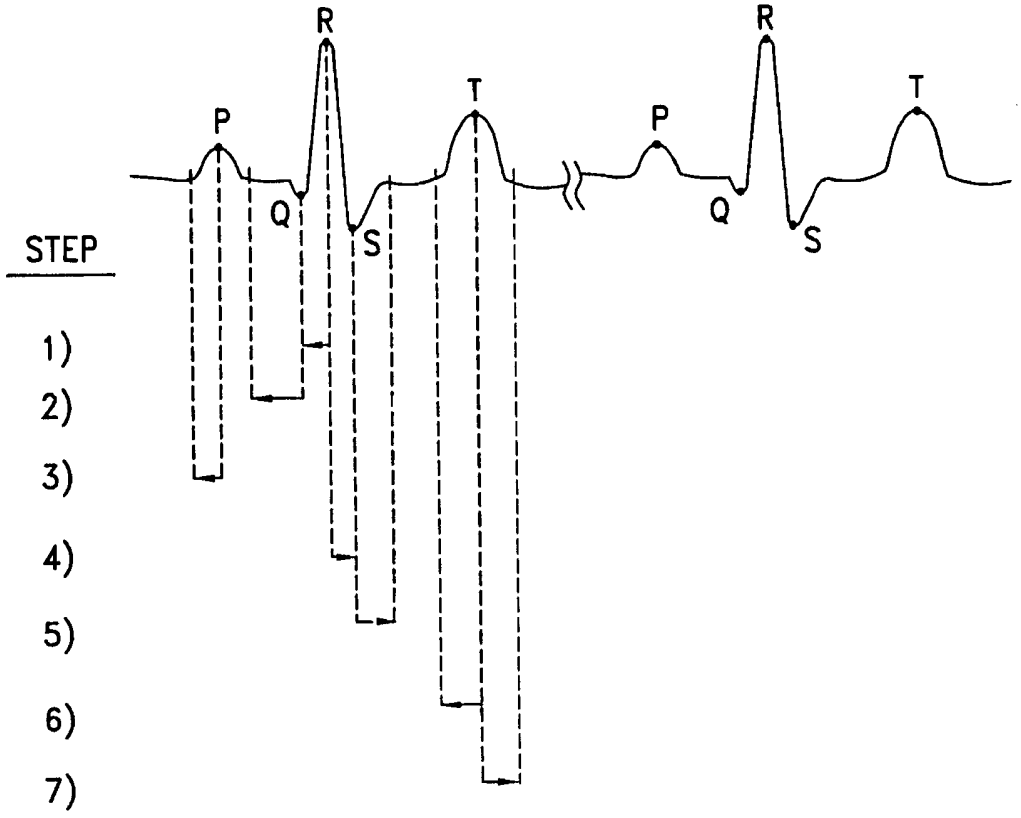

(d)
(e)
AR
AR
R
R
R
R
R
R
AR
AR
R
R
R
R
1000
900
800
700
600
500
400
300
200
100
0
800
600
400
200
0
-200
0
1
2
3
4
5
6

Fig. 8 (cont.)



STEP	GO...	FIND...
1	LEFT FROM R_{PEAK}	Q_{PEAK}
2	LEFT FROM Q_{PEAK}	Q_{ONSET}
3	LEFT FROM P_{PEAK}	P_{ONSET}
4	RIGHT FROM R_{PEAK}	S_{PEAK}
5	RIGHT FROM S_{PEAK}	S_{OFF}
6	LEFT FROM T_{PEAK}	T_{ONSET}
7	RIGHT FROM T_{PEAK}	T_{END}

Fig. 9

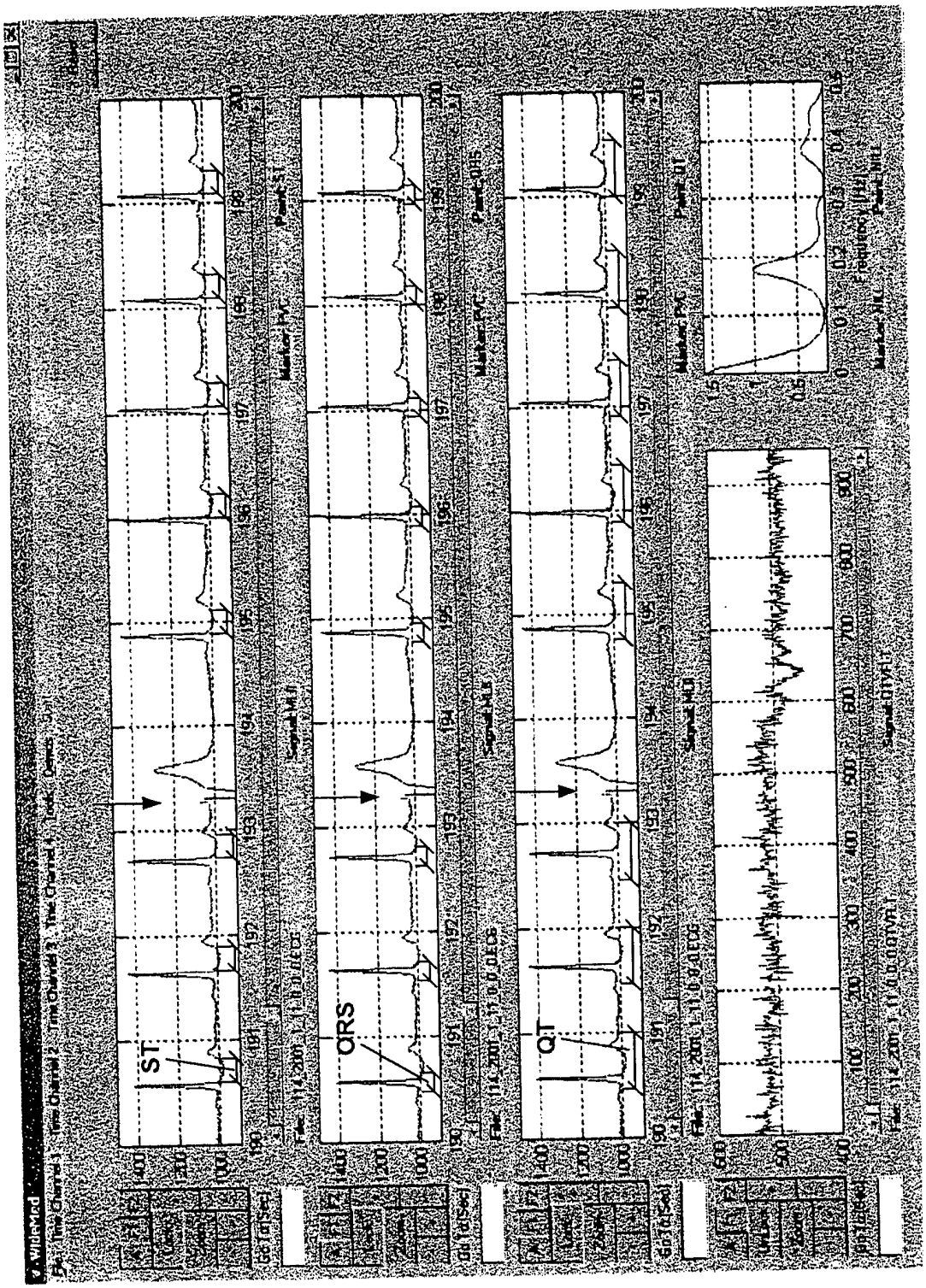


Fig. 10

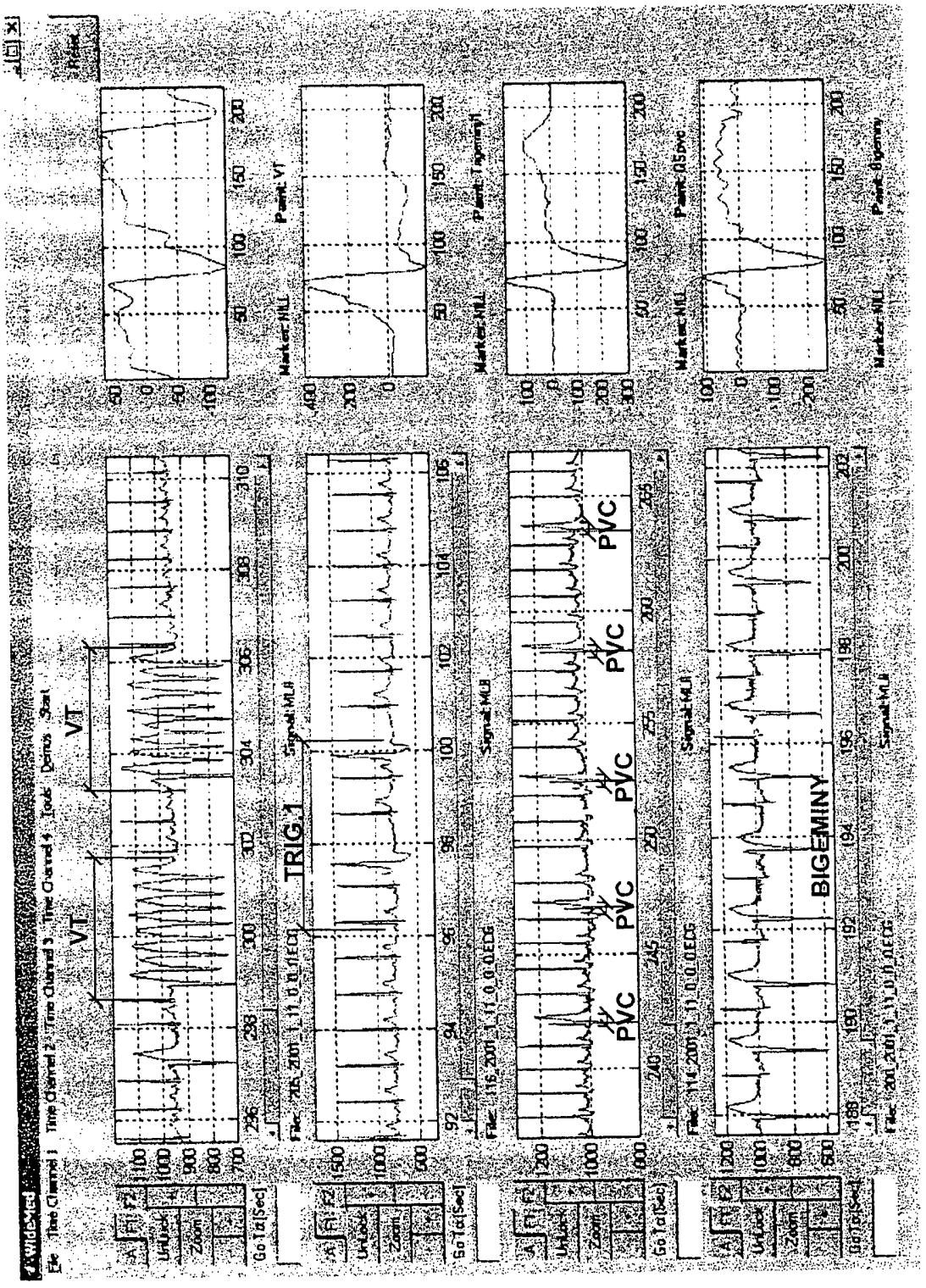


Fig. 11

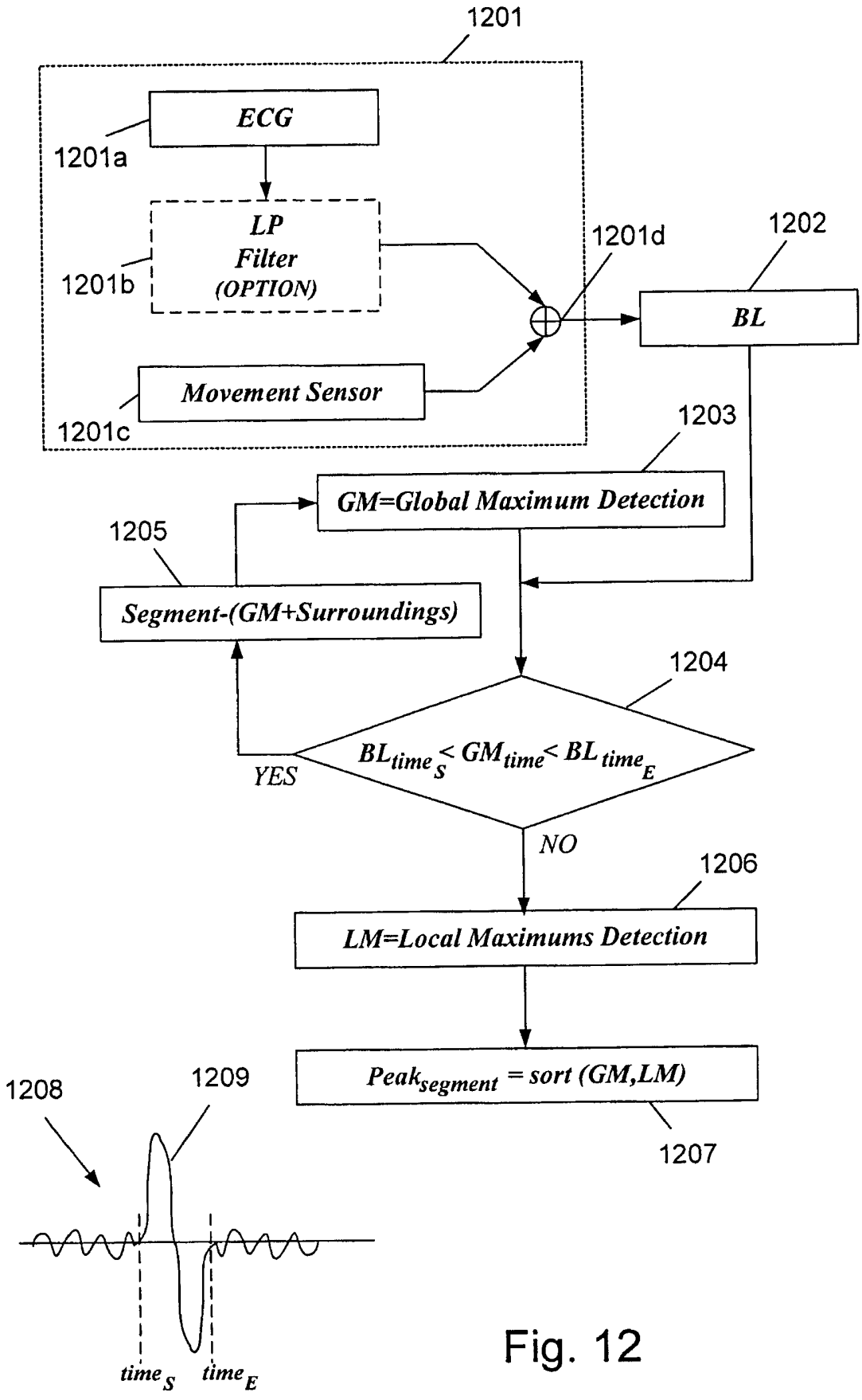

1201
ECG
1201a
LP
Filter
(OPTION)
1201b
Movement Sensor
1201c
1201d
1202
BL
1203
GM=Global Maximum Detection
1205
Segment-(GM+Surroundings)
1204
$BL_{time_S} < GM_{time} < BL_{time_E}$
YES
NO
1206
LM=Local Maximums Detection
$Peak_{segment}$ = sort (GM,LM)
1207
1208
1209
$time_S$
$time_E$

Fig. 12

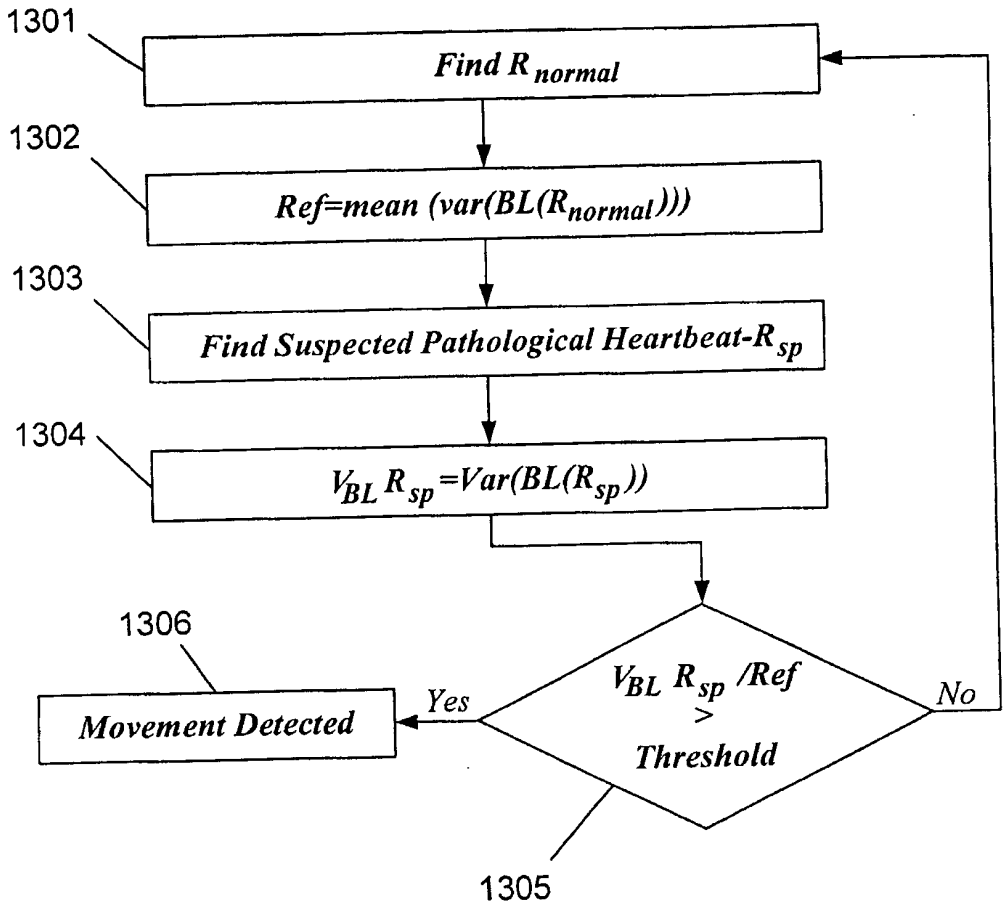

1301
Find R_{normal}
1302
Ref=mean (var(BL(R_{normal})))
1303
Find Suspected Pathological Heartbeat-R_{sp}
1304
V_{BL} R_{sp}=Var(BL(R_{sp}))
1306
Movement Detected
Yes
V_{BL} R_{sp} /Ref
>
Threshold
No
1305

Fig. 13

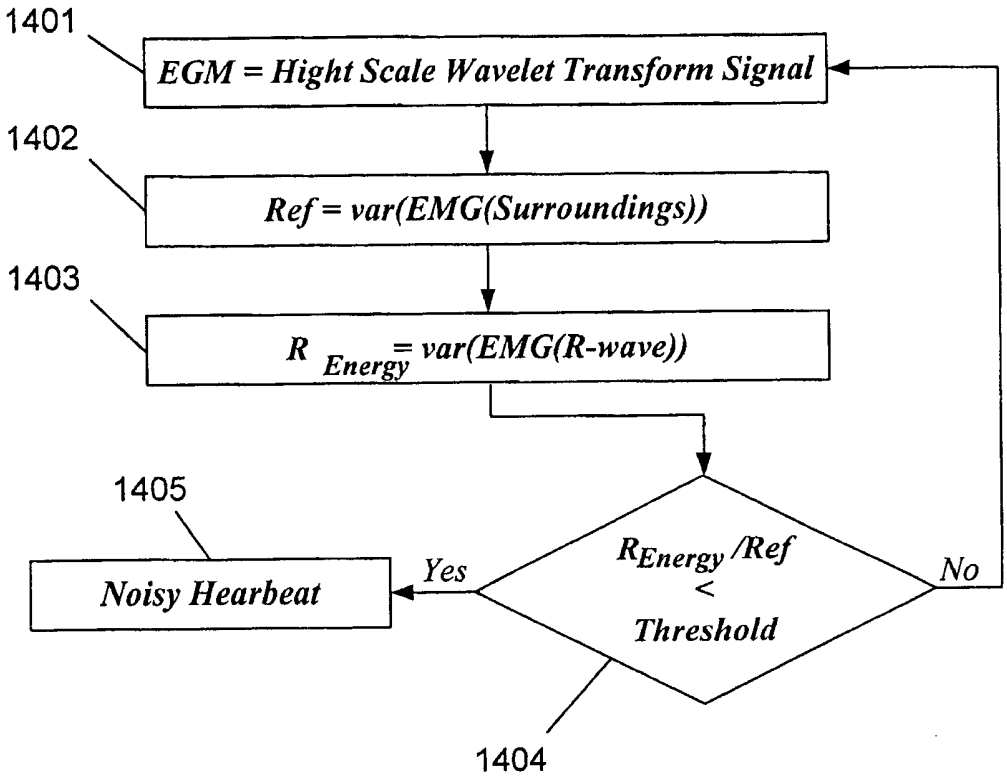

1401
EGM = Hight Scale Wavelet Transform Signal
1402
Ref = var(EMG(Surroundings))
1403
R Energy = var(EMG(R-wave))
1405
Noisy Hearbeat
Yes
R Energy /Ref
<
Threshold
No
1404

Fig. 14

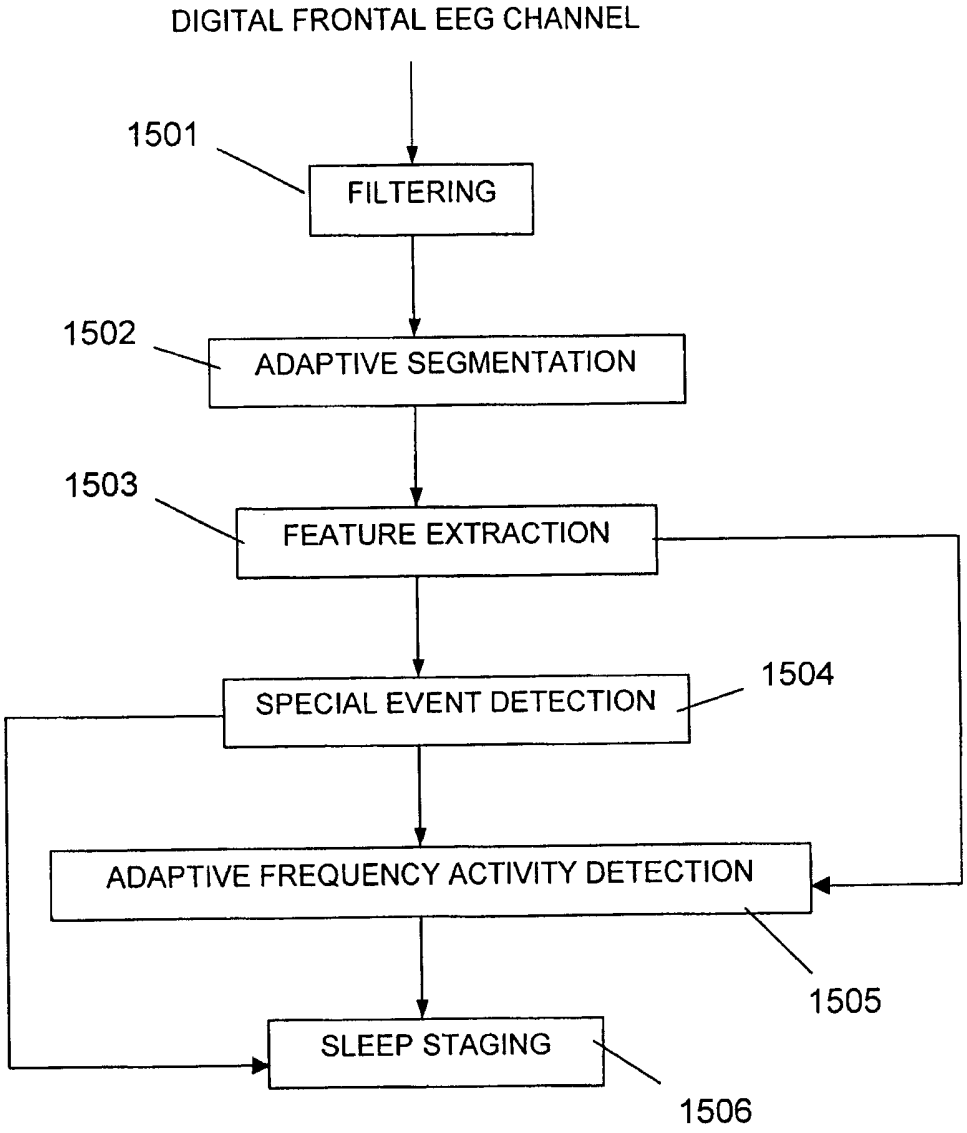

DIGITAL FRONTAL EEG CHANNEL
1501
FILTERING
1502
ADAPTIVE SEGMENTATION
1503
FEATURE EXTRACTION
SPECIAL EVENT DETECTION
1504
ADAPTIVE FREQUENCY ACTIVITY DETECTION
1505
SLEEP STAGING
1506

Fig. 15

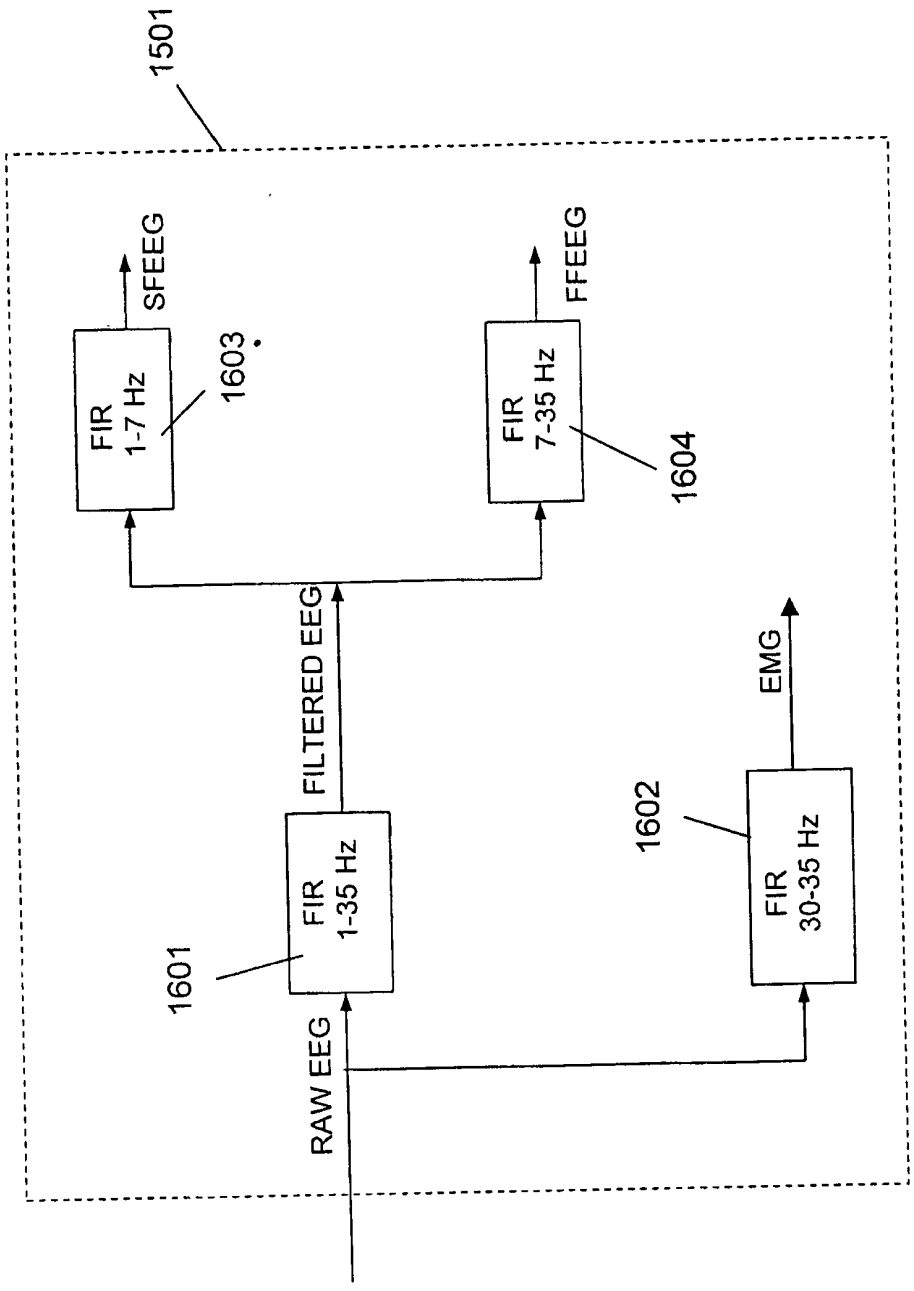

1501
SFEEG
FIR
1-7 Hz
1603
FFEEG
FIR
7-35 Hz
1604
FILTERED EEG
EMG
1602
FIR
30-35 Hz
1601
FIR
1-35 Hz
RAW EEG

Fig. 16

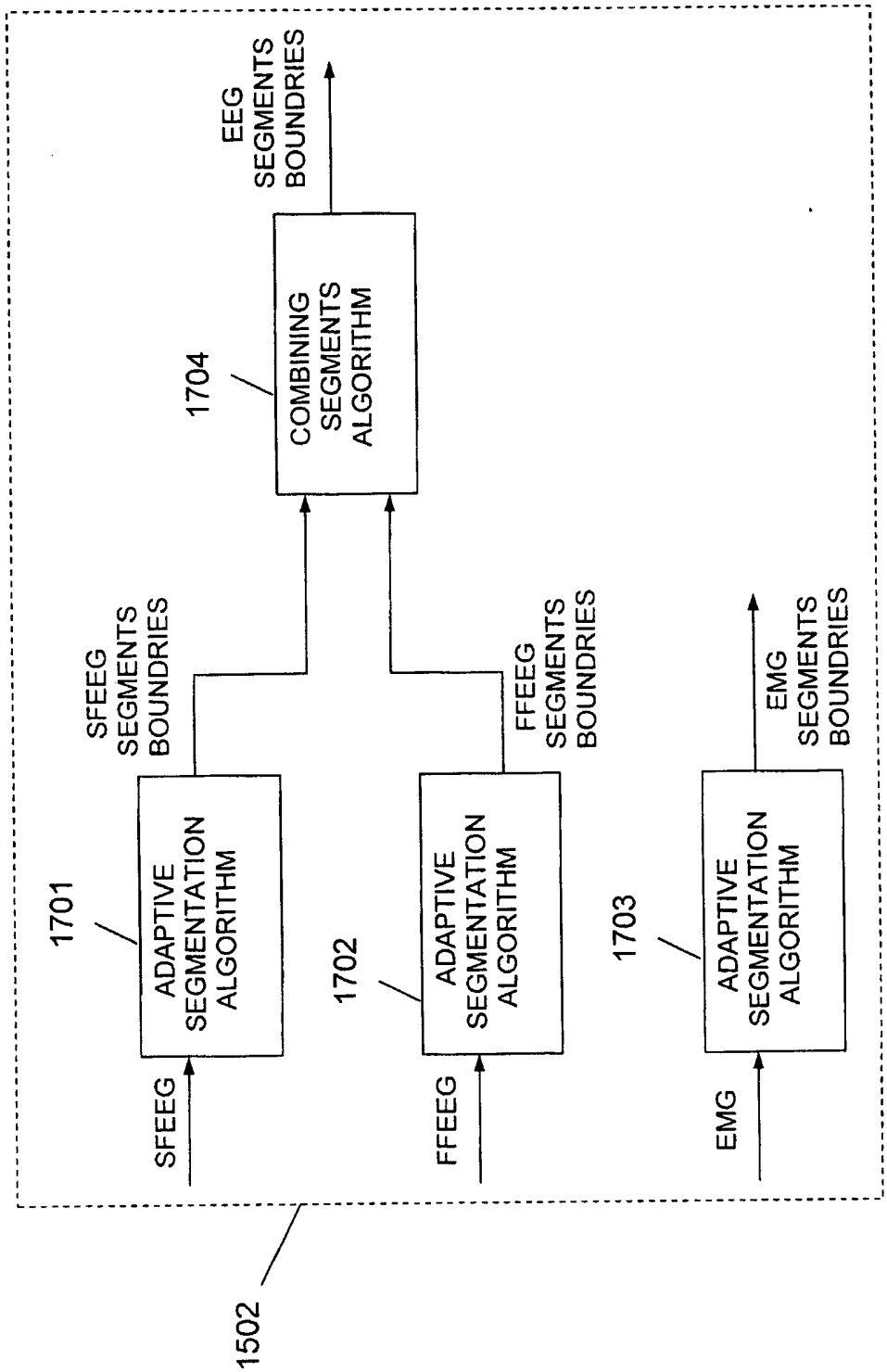
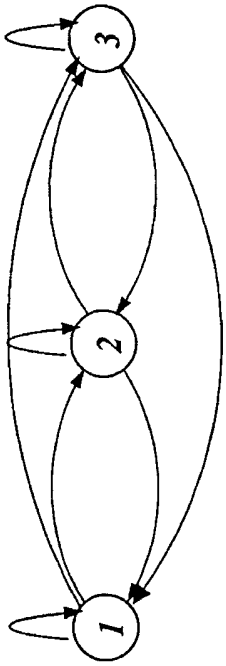
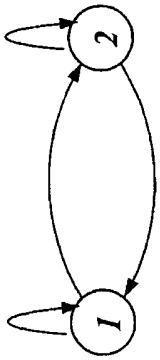

1502
SFEEG
FFEEG
EMG
1701
ADAPTIVE SEGMENTATION ALGORITHM
1702
ADAPTIVE SEGMENTATION ALGORITHM
1703
ADAPTIVE SEGMENTATION ALGORITHM
SFEEG SEGMENTS BOUNDRIES
FFEEG SEGMENTS BOUNDRIES
EMG SEGMENTS BOUNDRIES
1704
COMBINING SEGMENTS ALGORITHM
EEG SEGMENTS BOUNDRIES

Fig. 17



(a)



(b)

Fig. 18

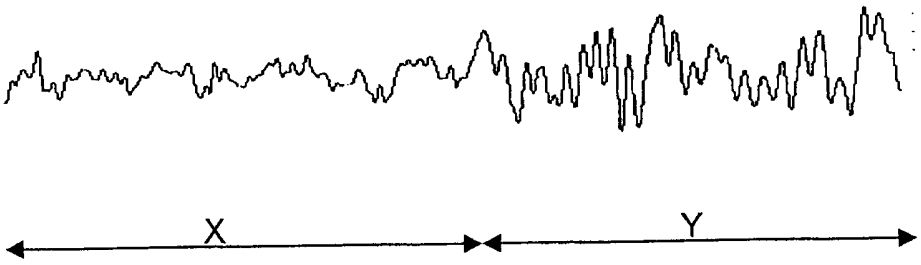


Fig. 19

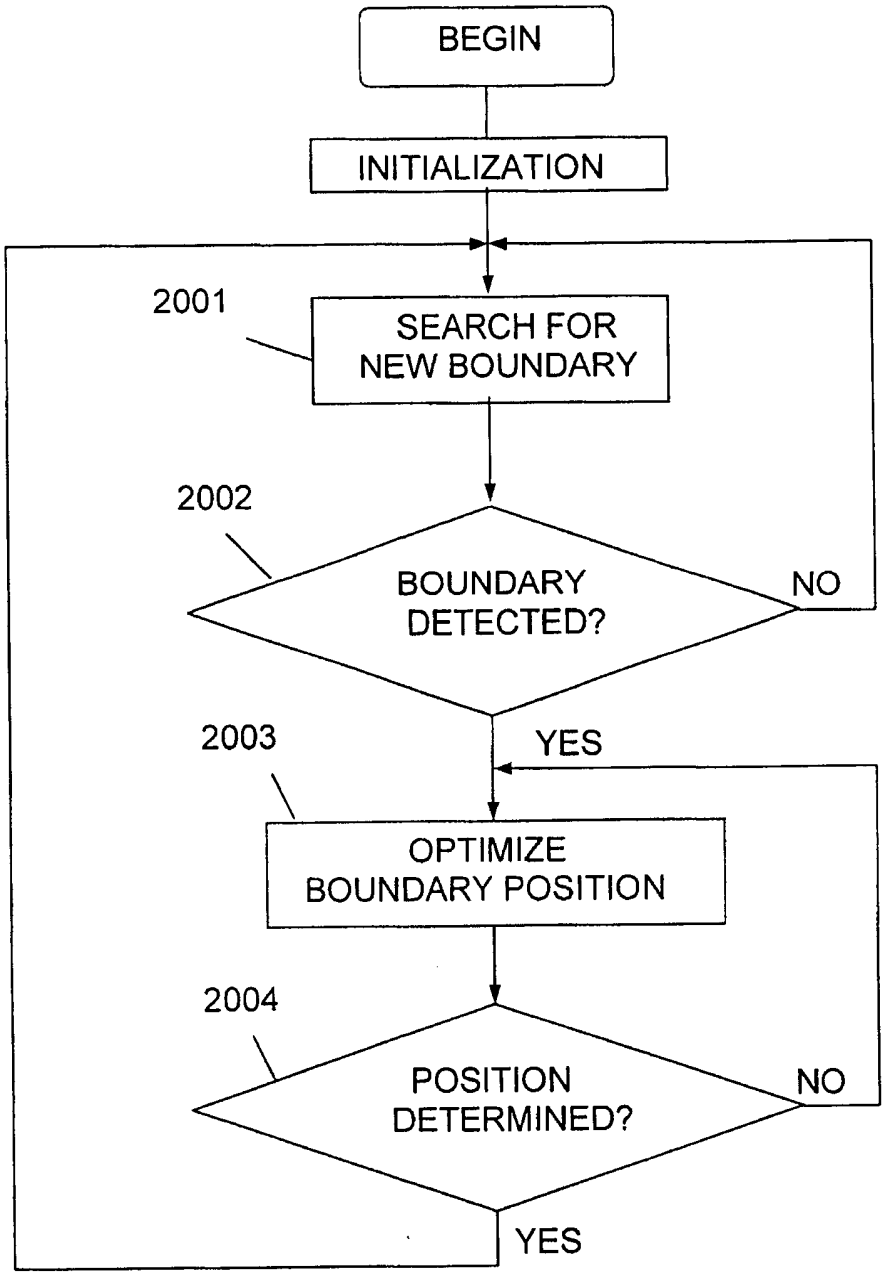

BEGIN
INITIALIZATION
2001
SEARCH FOR NEW BOUNDARY
2002
BOUNDARY DETECTED?
NO
YES
2003
OPTIMIZE BOUNDARY POSITION
2004
POSITION DETERMINED?
NO
YES

Fig. 20

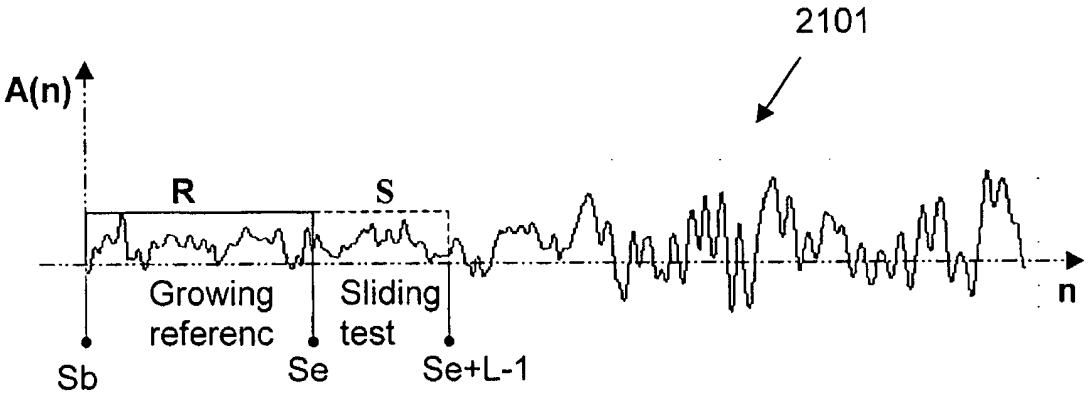


Fig. 21a

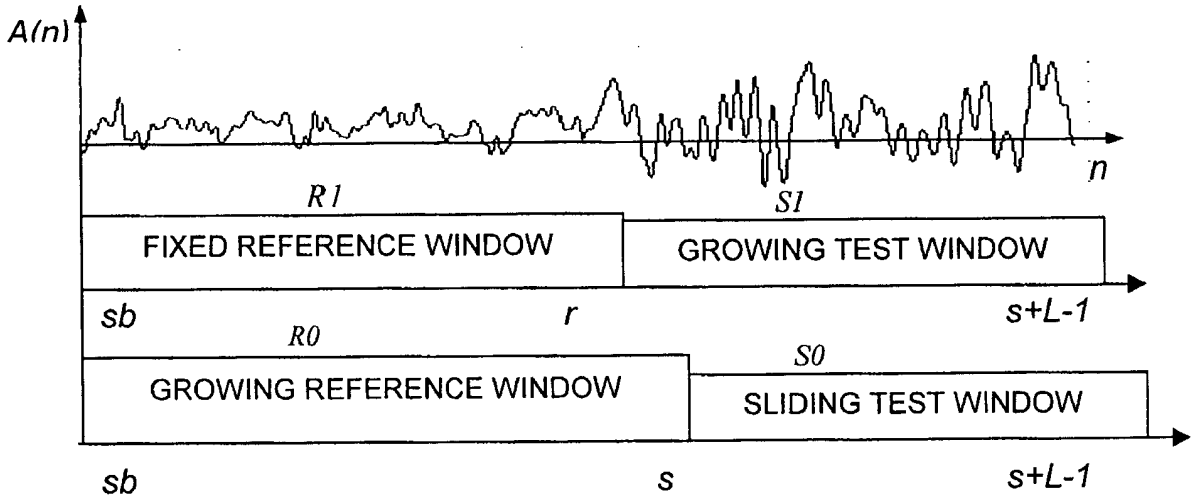


Fig. 21b

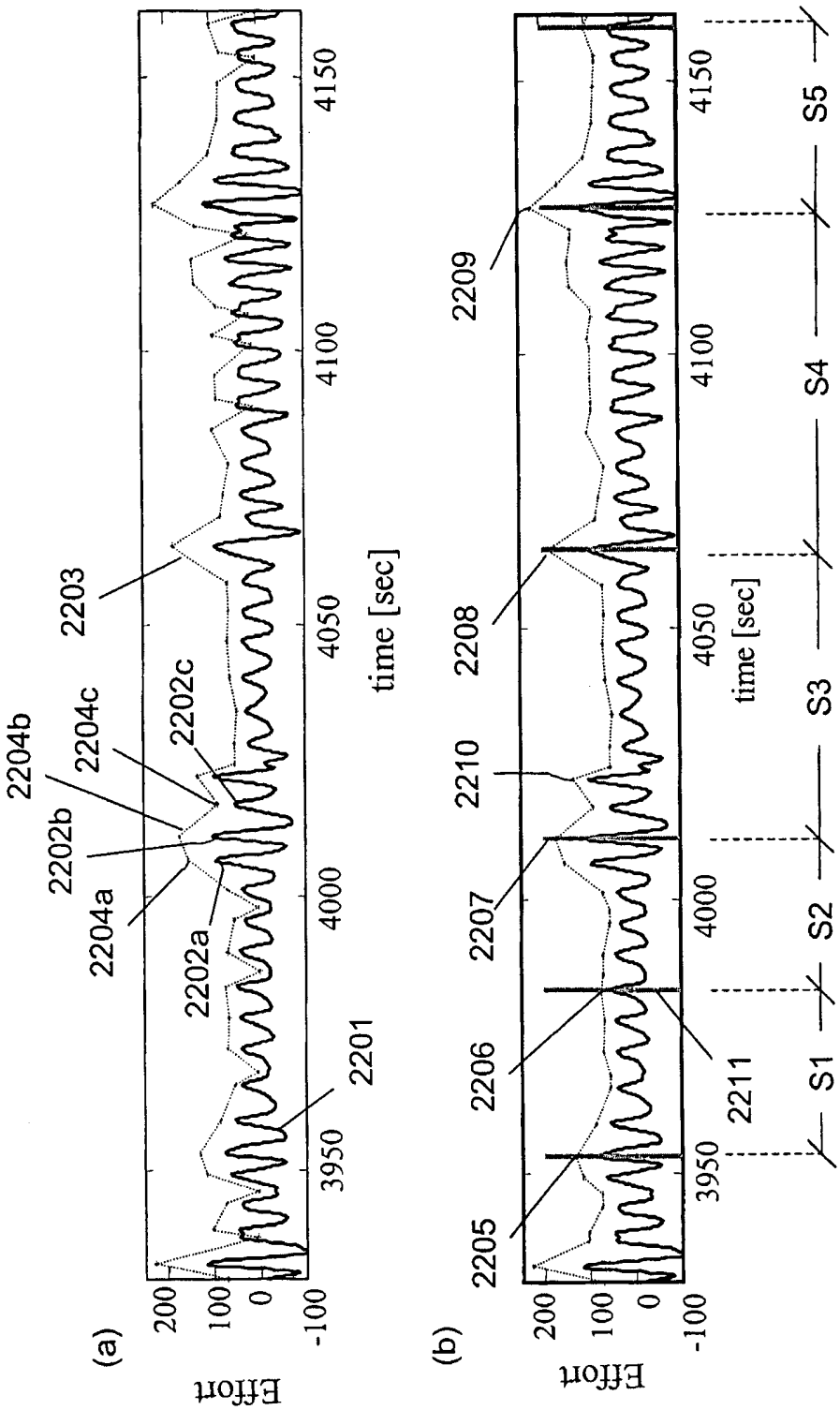

(a)
Effort
200
100
0
-100
3950
4000
4050
4100
4150
time [sec]
2201
2202a
2202b
2202c
2203
2204a
2204b
2204c
(b)
Effort
200
100
0
-100
3950
4000
4050
4100
4150
time [sec]
2205
2206
2207
2208
2209
2210
2211
S1
S2
S3
S4
S5

Fig. 22

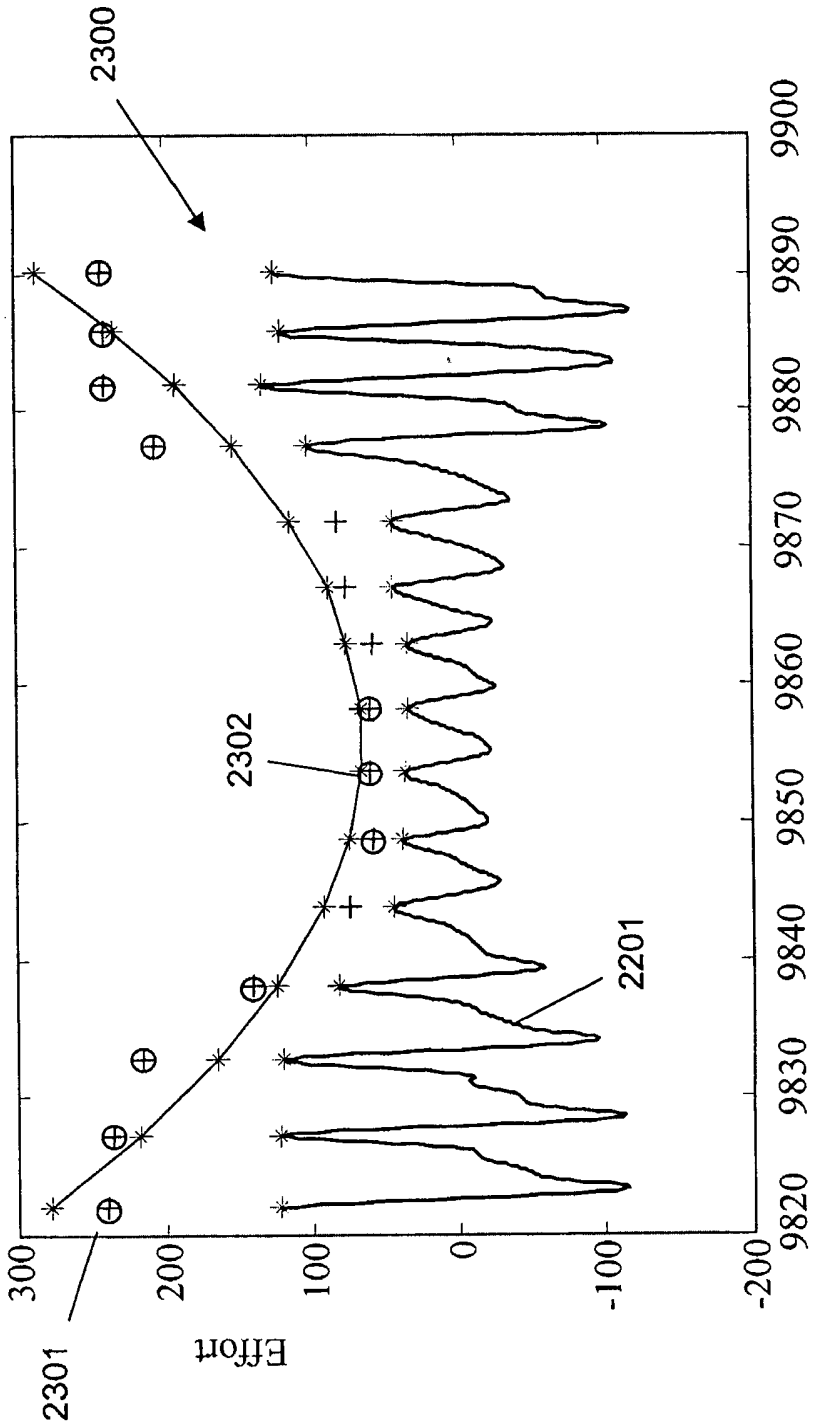

2300
2302
2301
2201
Effort
time [sec]
300
200
100
0
-100
-200
9820
9830
9840
9850
9860
9870
9880
9890
9900

Fig. 23

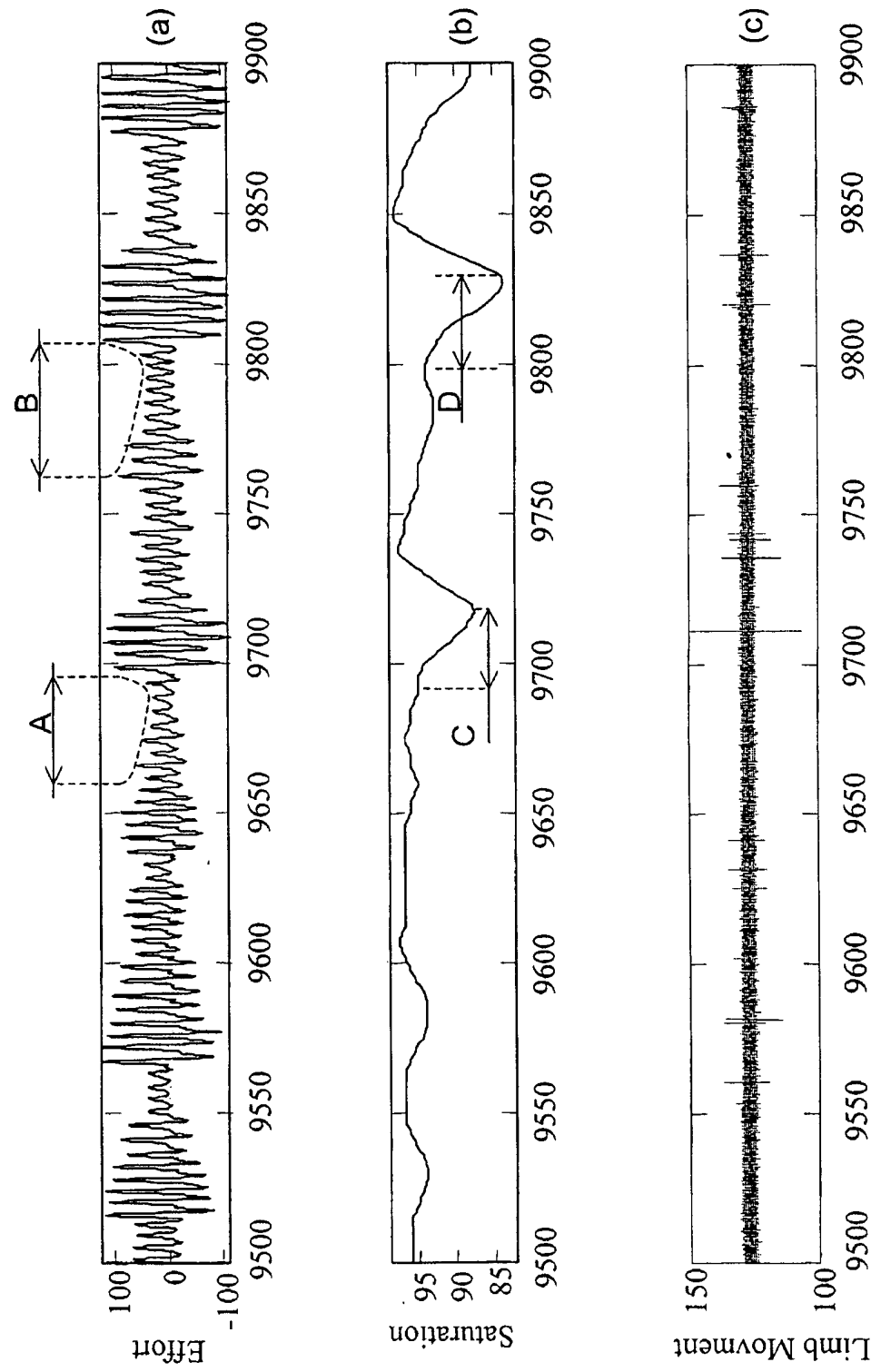

(a)
(b)
(c)
A
B
C
D
Effort
Saturation
Limb Movement
time [sec]
100
0
-100
95
90
85
150
100
9500
9550
9600
9650
9700
9750
9800
9850
9900

Fig. 24

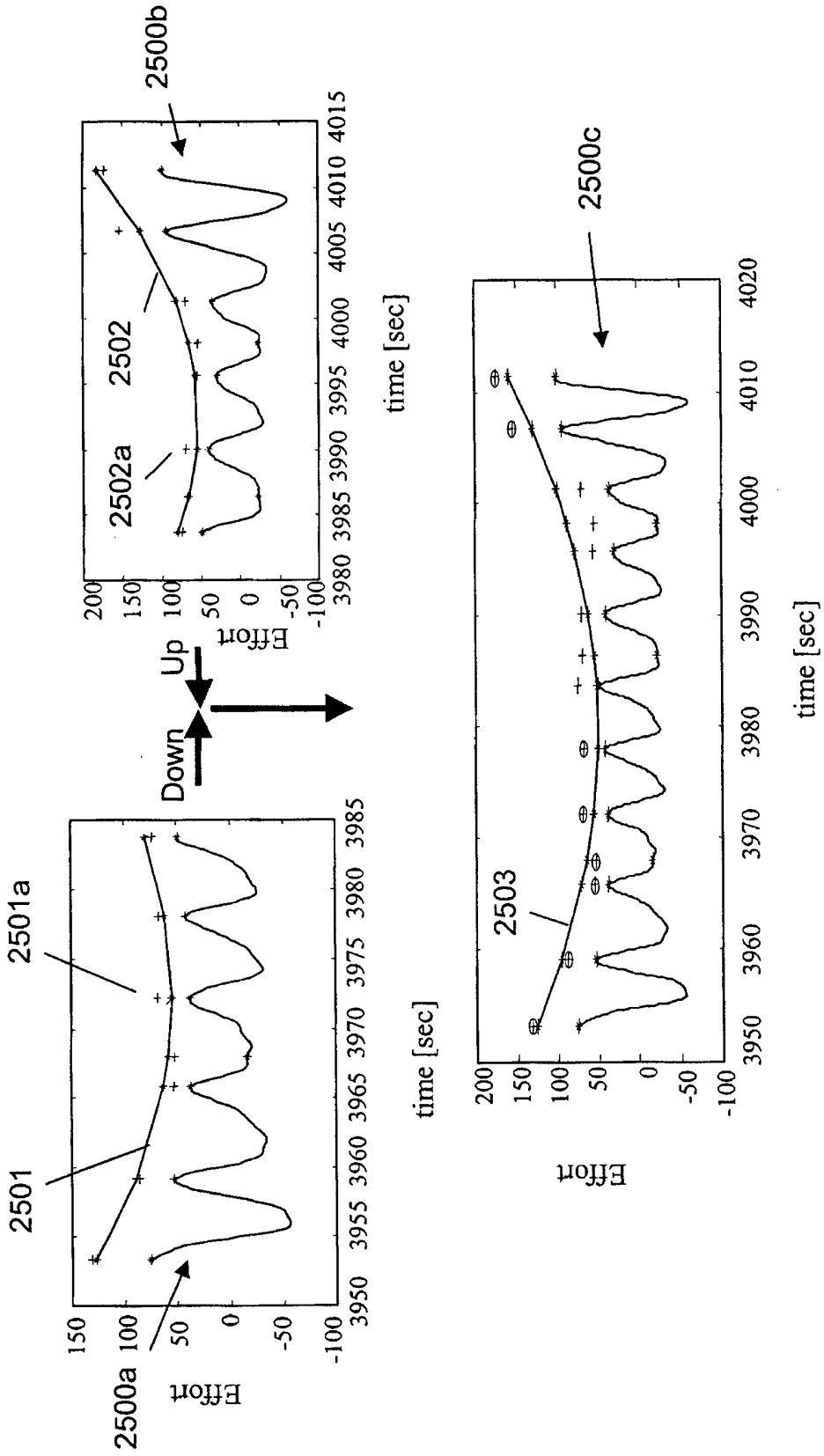

2500b
2502
2502a
Effort
time [sec]
Up
Down
2501
2501a
2500a
2500c
2503

Fig. 25

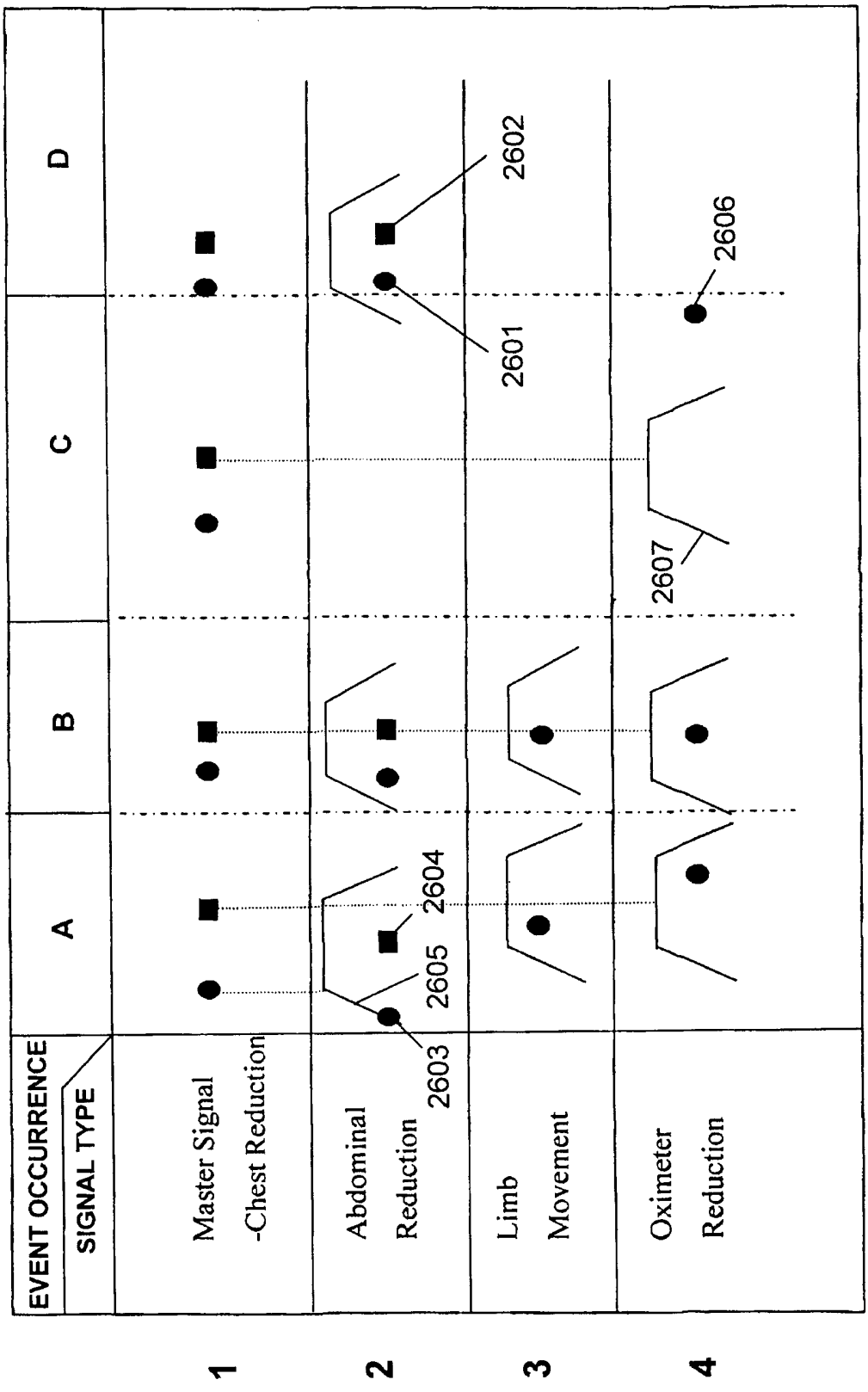

EVENT OCCURRENCE
SIGNAL TYPE
A
B
C
D
Master Signal
-Chest Reduction
Abdominal
Reduction
Limb
Movement
Oximeter
Reduction
1
2
3
4
2601
2602
2603
2604
2605
2606
2607

Fig. 26

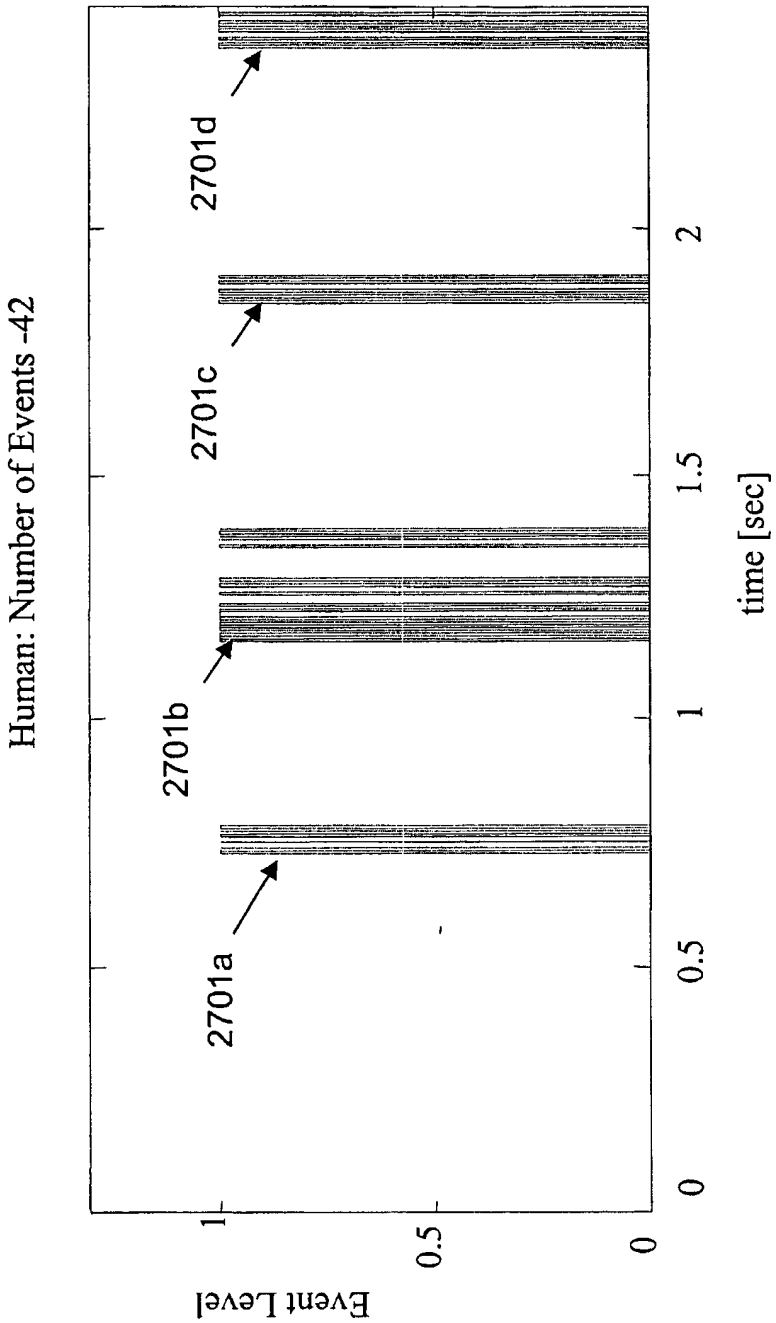

Human: Number of Events -42
Event Level
0
0.5
1
0
0.5
1
1.5
2
time [sec]
2701a
2701b
2701c
2701d

Fig. 27

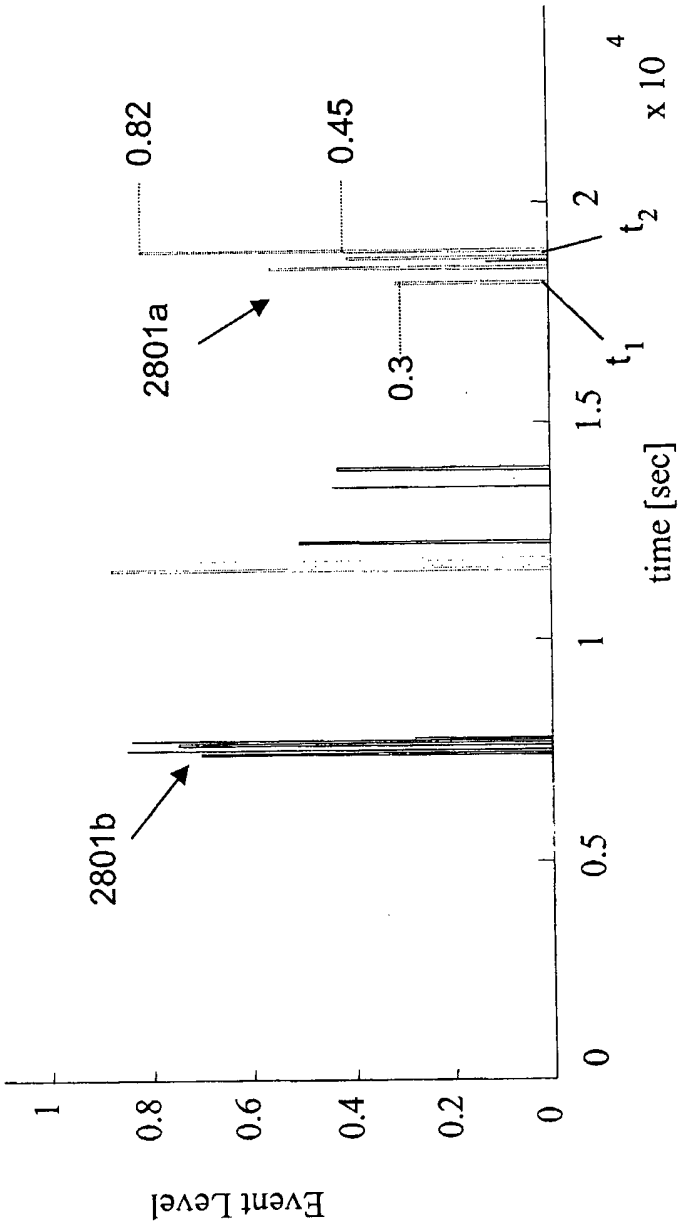

Event Level
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
x 10^4
time [sec]
0.82
0.45
0.3
2801a
2801b
t1
t2

Fig. 28

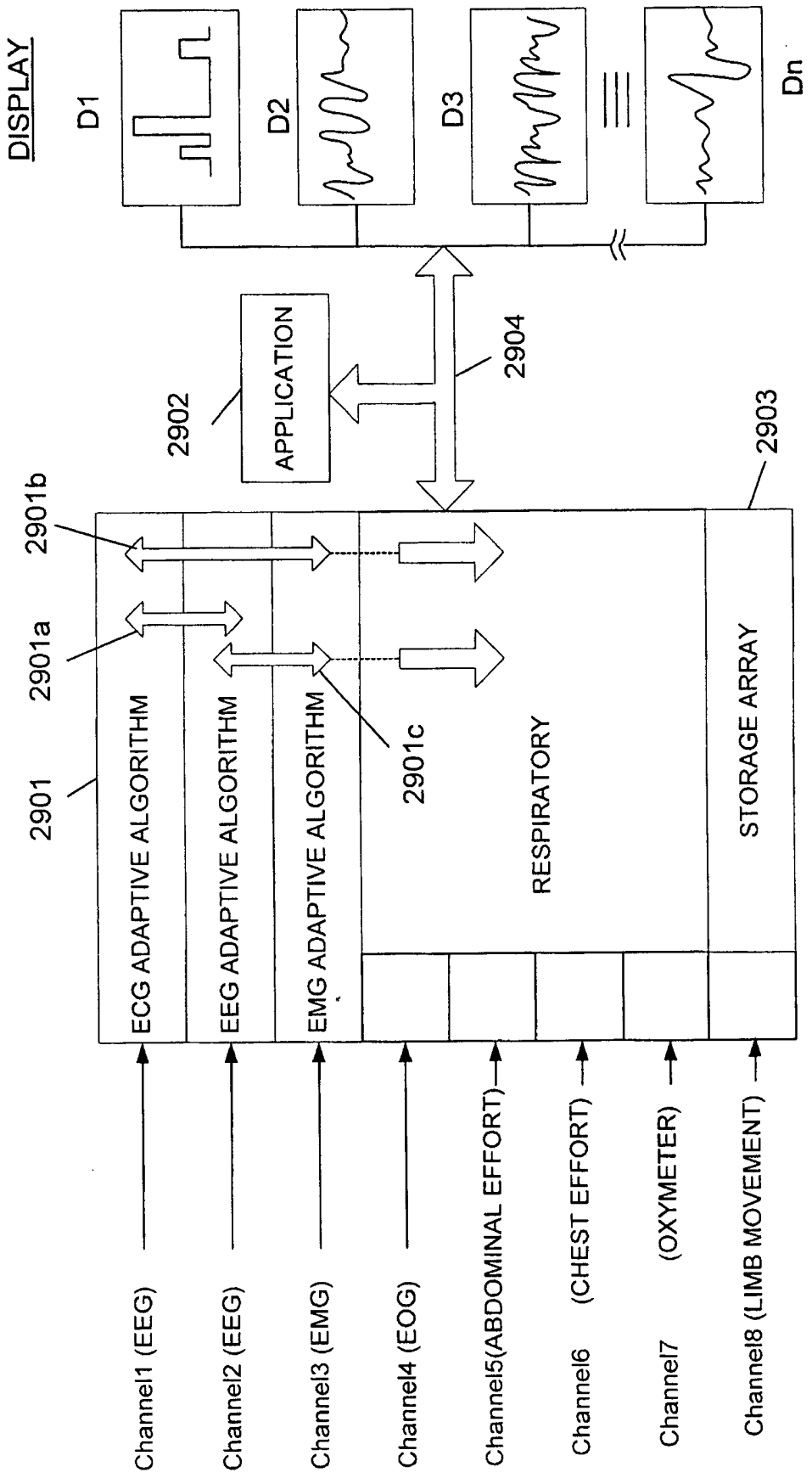

DISPLAY
D1
D2
D3
Dn
2902
APPLICATION
2904
2903
2901b
2901a
2901
2901c
ECG ADAPTIVE ALGORITHM
EEG ADAPTIVE ALGORITHM
EMG ADAPTIVE ALGORITHM
RESPIRATORY
STORAGE ARRAY
Channel1 (EEG)
Channel2 (EEG)
Channel3 (EMG)
Channel4 (EOG)
Channel5(ABDOMINAL EFFORT)
Channel6 (CHEST EFFORT)
Channel7 (OXYMETER)
Channel8 (LIMB MOVEMENT)

Fig. 29

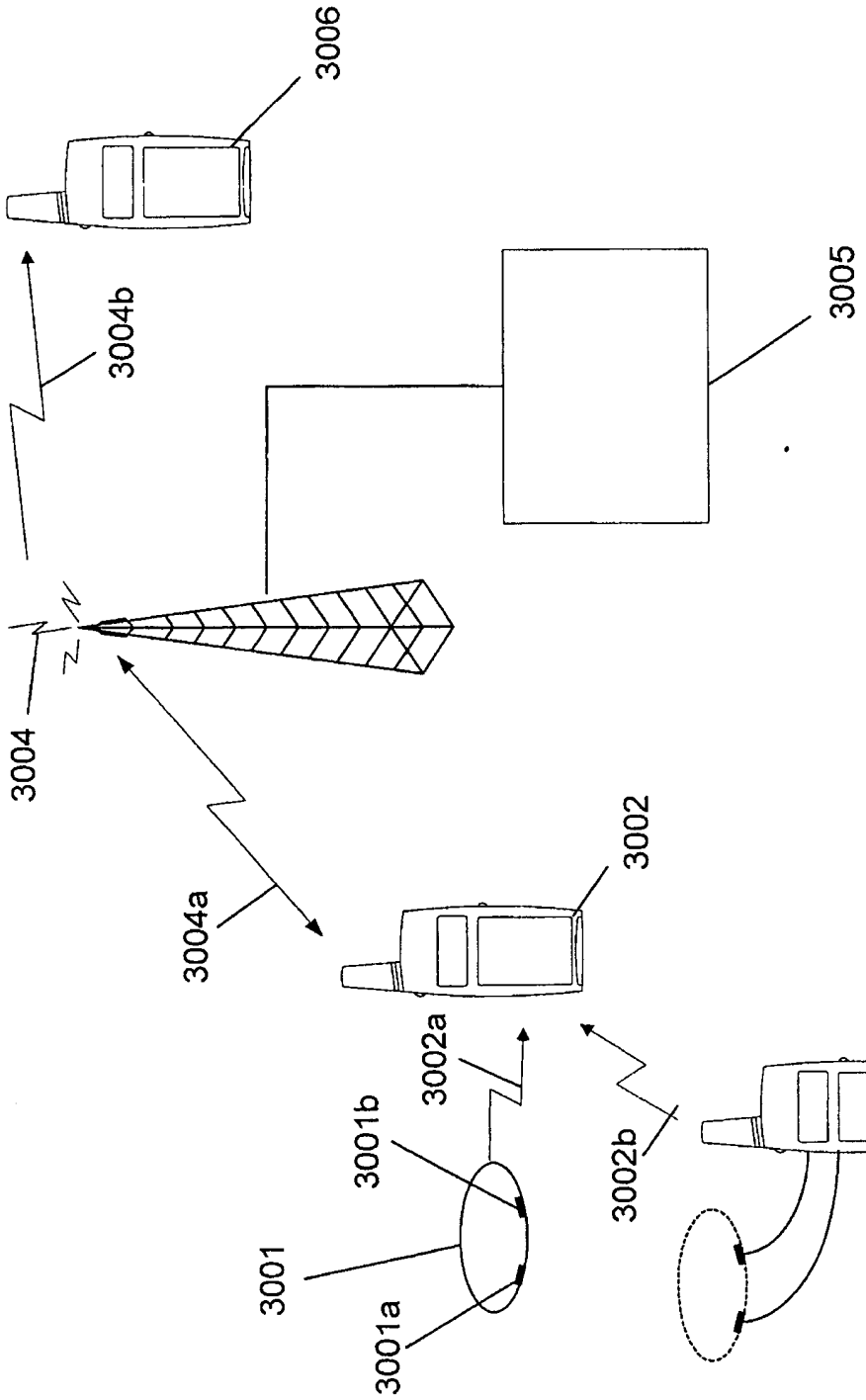

3006
3004b
3005
3004
3004a
3002
3002a
3001b
3001
3001a
3002b
3003

Fig. 30

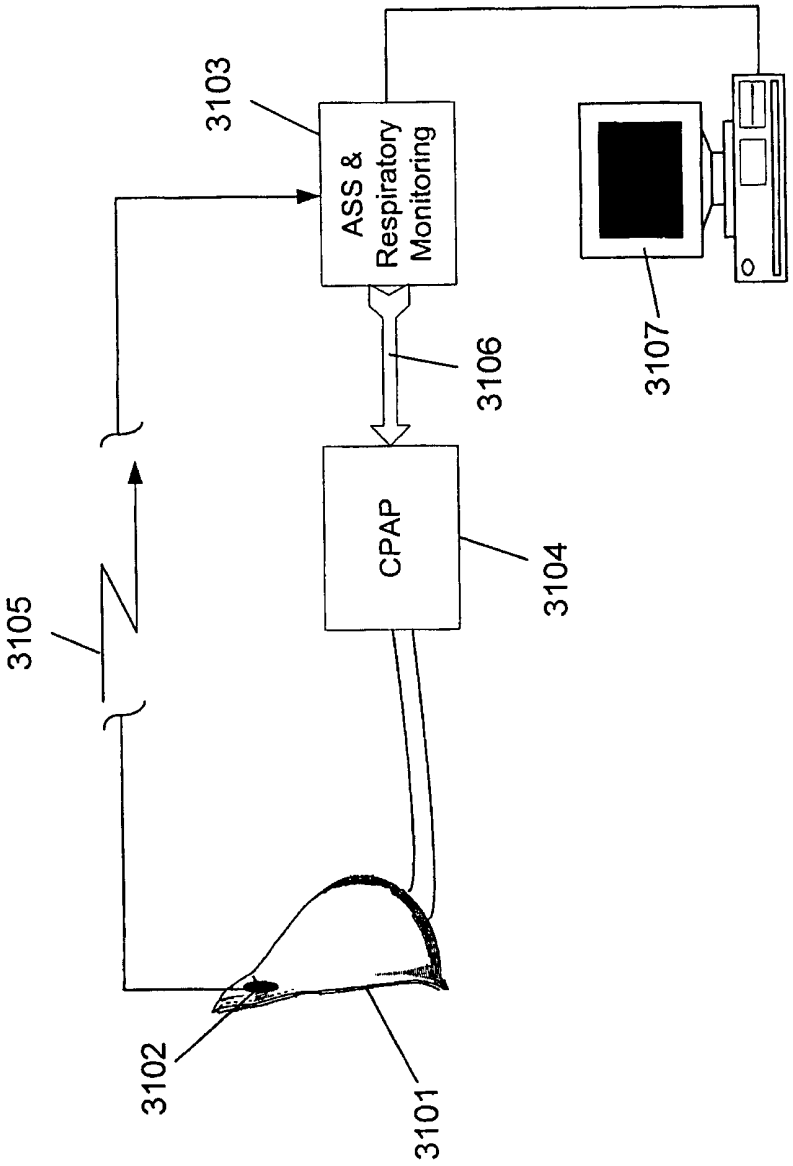

3103
ASS & Respiratory Monitoring
3106
3107
CPAP
3104
3105
3102
3101

Fig. 31

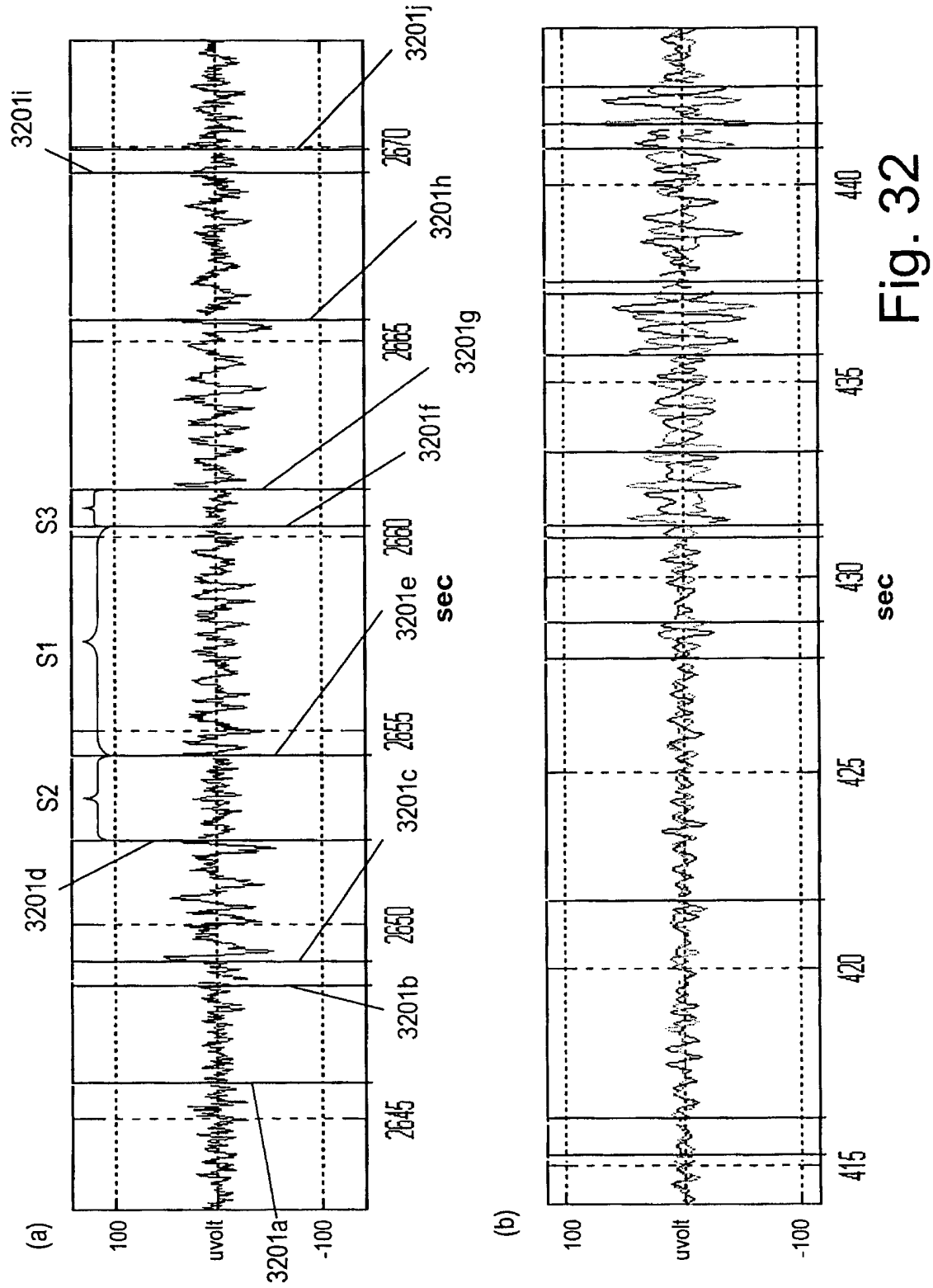

(a)
100
uvolt
-100
3201a
2645
2650
2655
2660
2665
2670
sec
S1
S2
S3
3201b
3201c
3201d
3201e
3201f
3201g
3201h
3201i
3201j
(b)
100
uvolt
-100
415
420
425
430
435
440
sec

Fig. 32

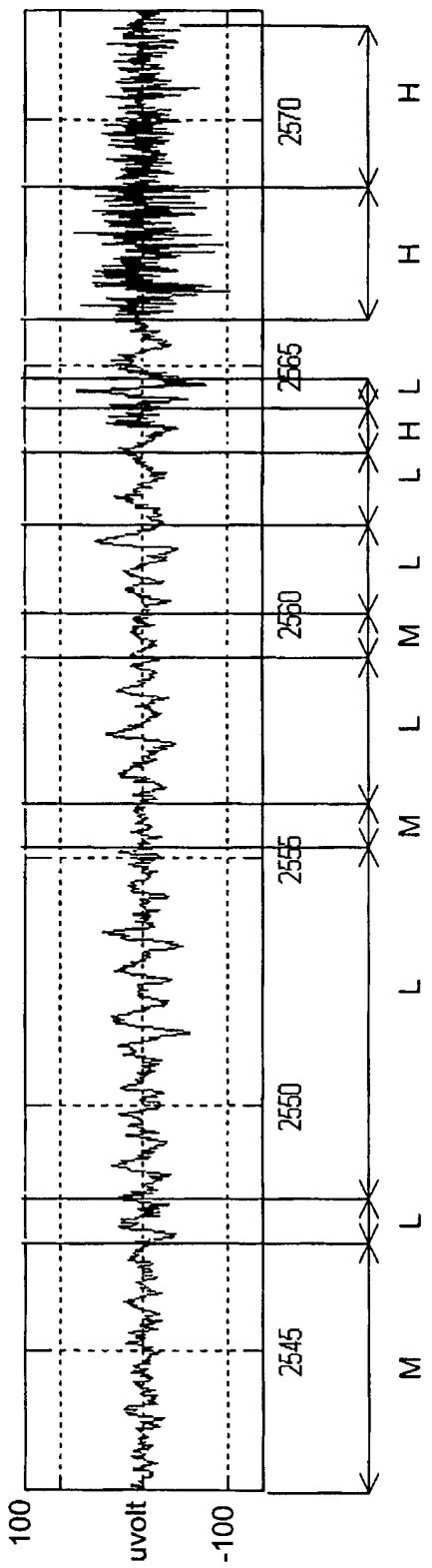


Fig. 33

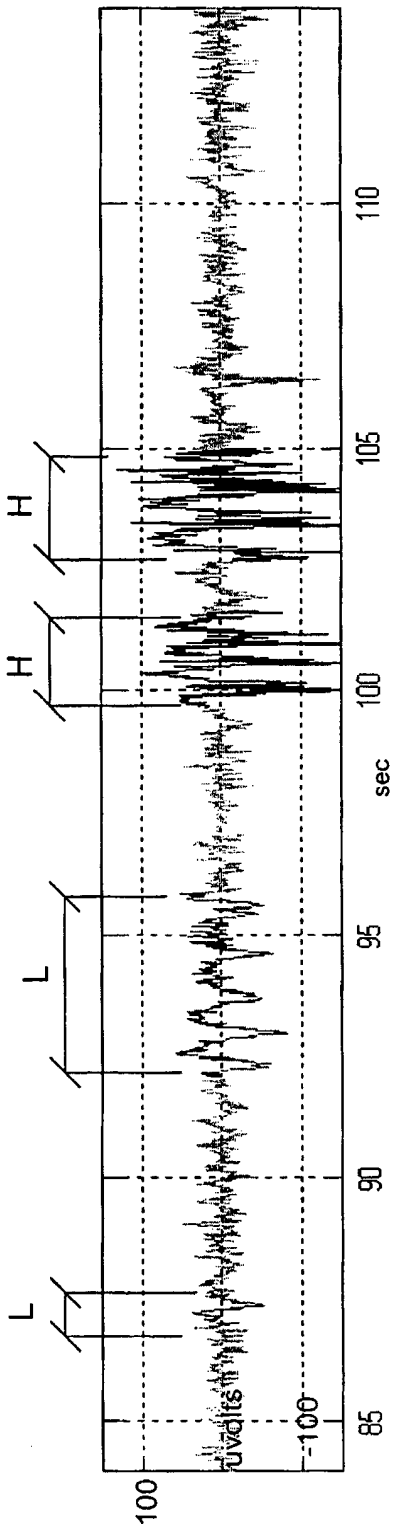


Fig. 34

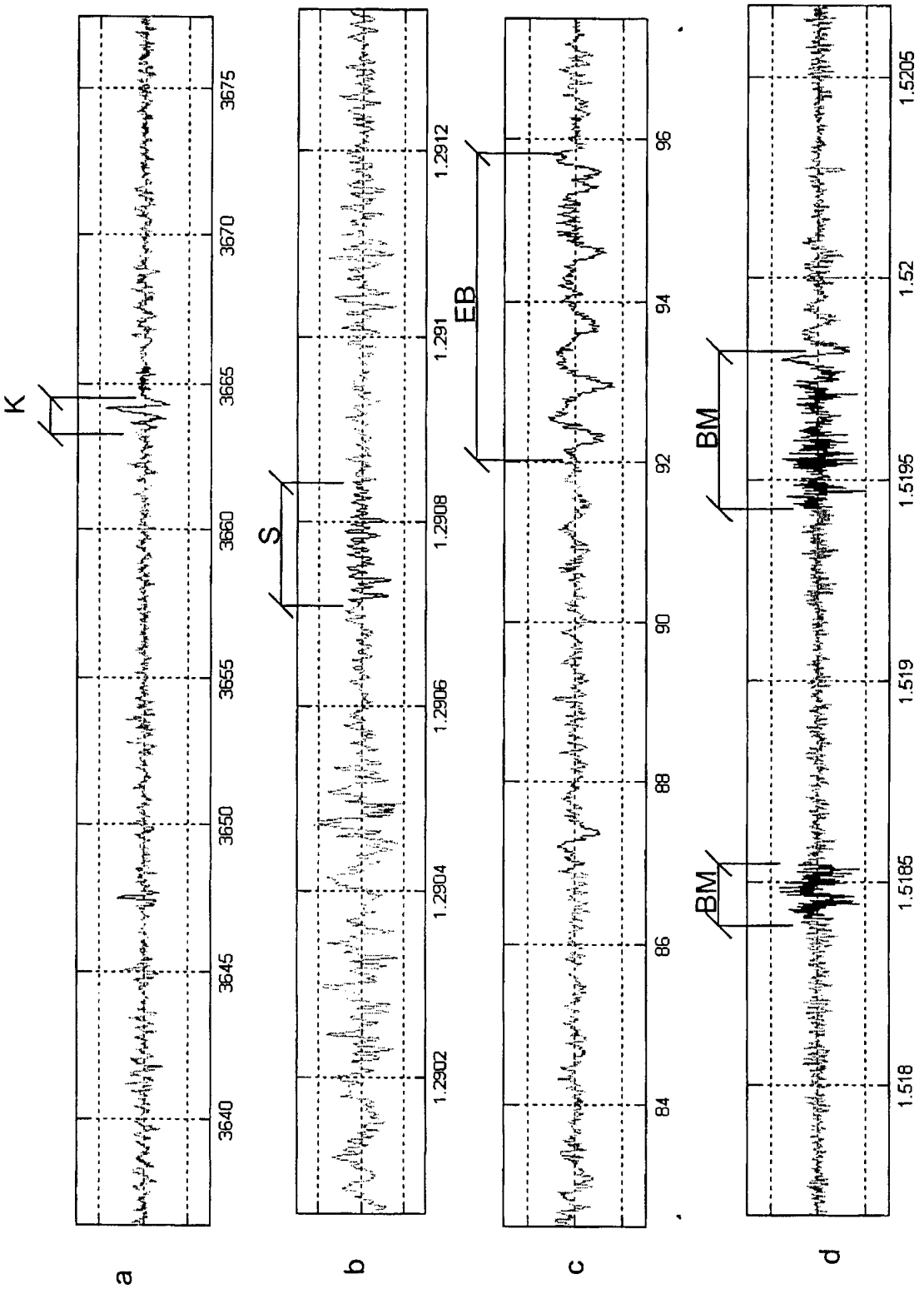

K
S
EB
BM
BM
a
b
c
d
3640
3645
3650
3655
3660
3665
3670
3675
1.2902
1.2904
1.2906
1.2908
1.291
1.2912
84
86
88
90
92
94
96
1.518
1.5185
1.519
1.5195
1.52
1.5205

Fig. 35

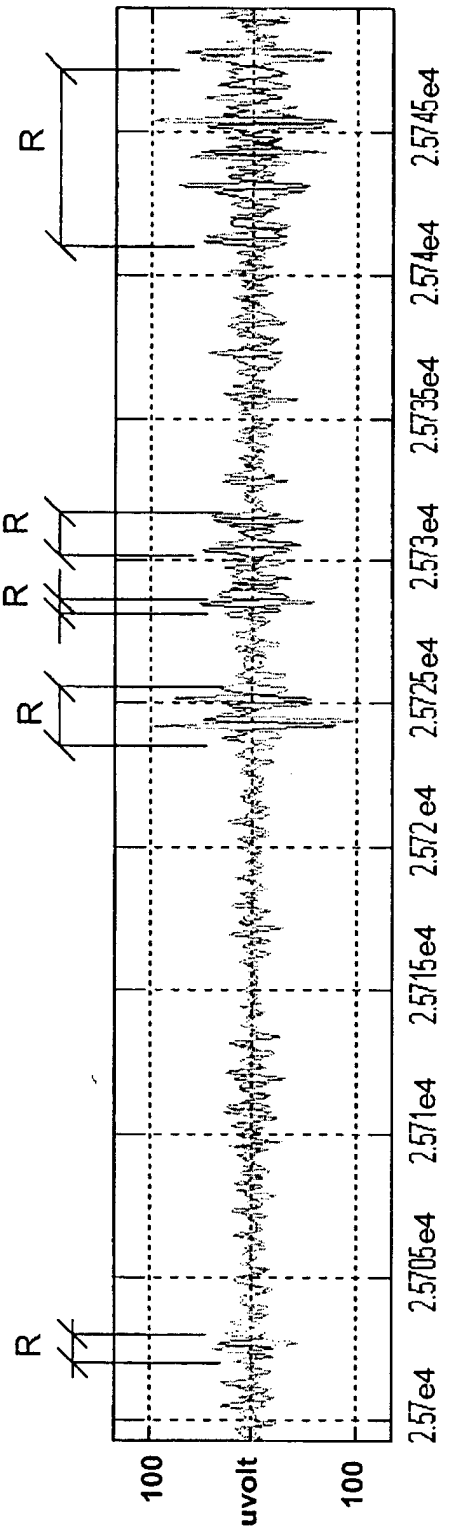

R
R
R R
R
R
100
uvolt
100
2.57e4
2.5705e4
2.571e4
2.5715e4
2.572e4
2.5725e4
2.573e4
2.5735e4
2.574e4
2.5745e4
sec

Fig. 36

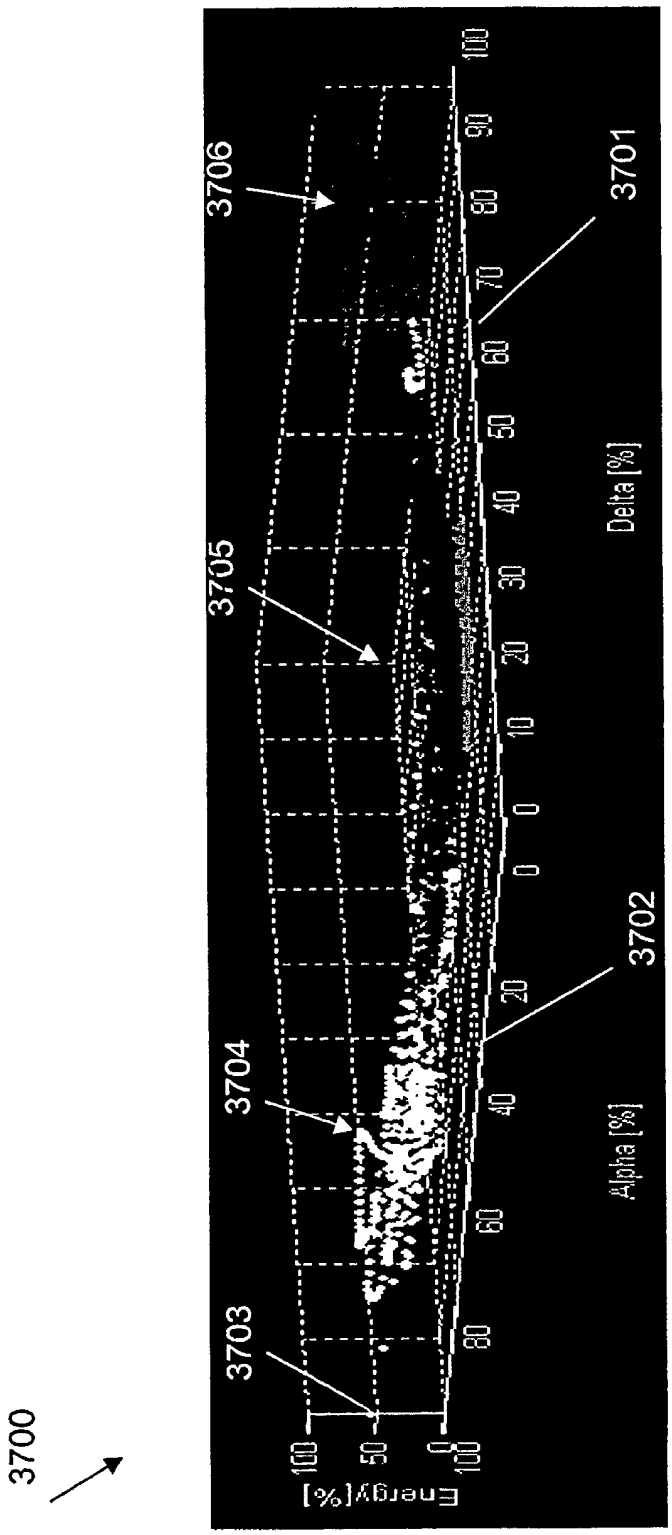


Fig. 37

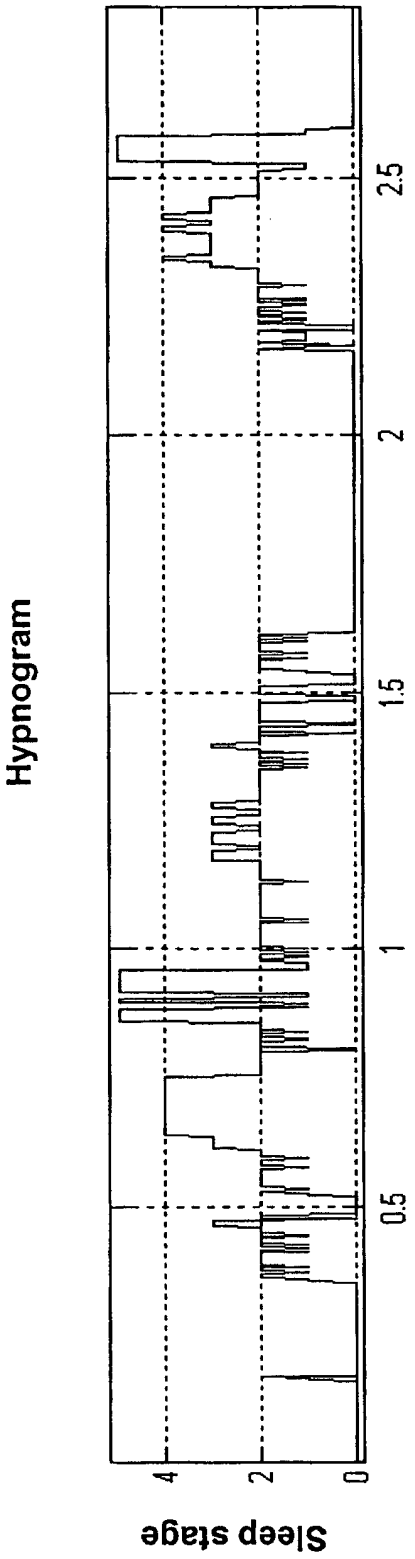


Fig. 38

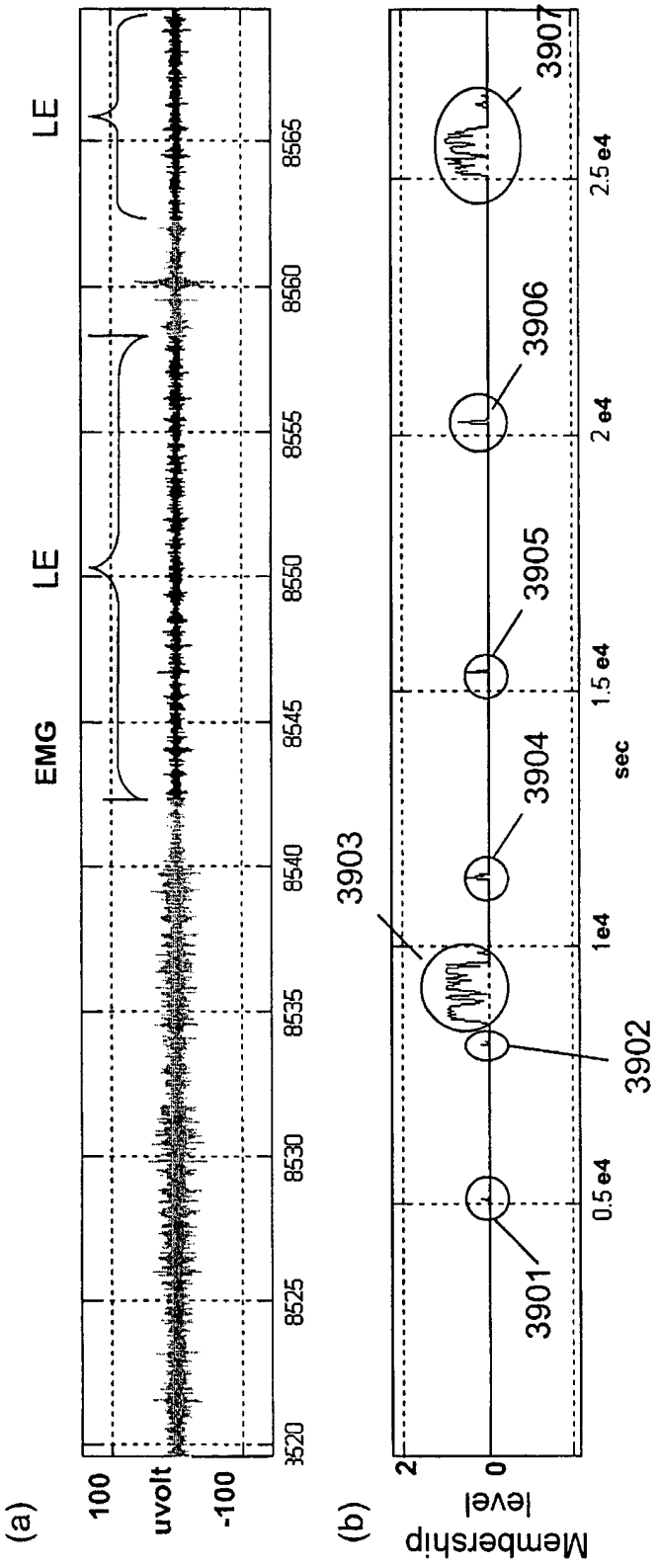

(a)
EMG
LE
LE
100
uvolt
-100
8520
8525
8530
8535
8540
8545
8550
8555
8560
8565
(b)
Membership level
2
0
3901
3902
3903
3904
3905
3906
3907
0.5 e4
1e4
1.5 e4
2 e4
2.5 e4
sec

Fig. 39

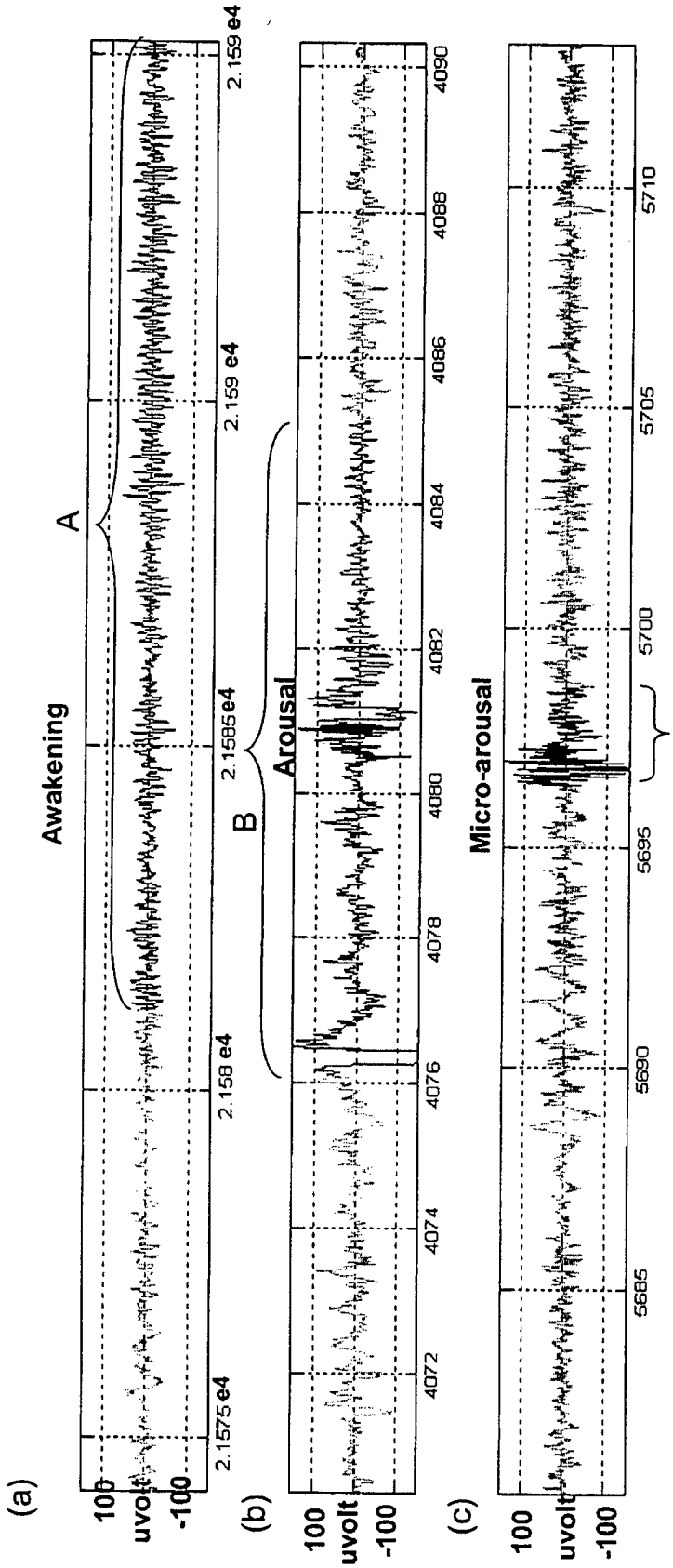

(a)
Awakening
A
100
uvolt
-100
2.1575 e4
2.158 e4
2.159 e4
(b)
B
Arousal
2.1585e4
2.159 e4
100
uvolt
-100
4072
4074
4076
4078
4080
4082
4084
4086
4088
4090
(c)
Micro-arousal
C
100
uvolt
-100
5685
5690
5695
5700
5705
5710
sec

Fig. 40